This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

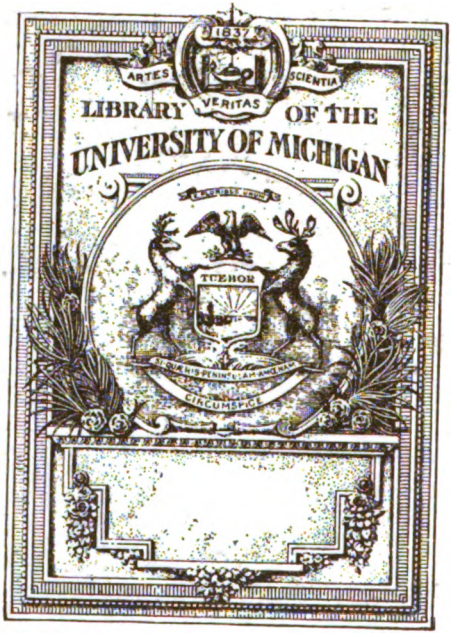
+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`



THE GIFT OF
H. D. Nutt

Digitized by Google

Mathemati
QA
1
.S3

Digitized by Google

Digitized by Google

Digitized by Google

Digitized by Google

Vol. XX. No. 1 Whole No. 165

JANUARY 1920

SCHOOL SCIENCE AND MATHEMATICS

A Journal for All Science and Mathematics Teachers

Founded by C. E. Linebarger

SMITH & TURTON, Publishers

Publication Office, Mount Morris, Illinois

CHICAGO OFFICE, 2059 East 72nd Place, CHICAGO, ILL.

CHARLES H. SMITH
EDITOR
Hyde Park High School, Chicago

CHARLES M. TURTON
BUSINESS MANAGER
Bowen High School, Chicago

DEPARTMENTAL EDITORS

Agriculture—Aretas W. Nolan
The University of Illinois, Urbana, Ill.

Astronomy—George W. Myers
The University of Chicago

Biology, Research in—Homer C. Sampson
The Ohio State University, Columbus

Botany—

Chemistry—Frank B. Wade
Shortridge High School, Indianapolis, Ind.

Chemistry, Research in—B. S. Hopkins
The University of Illinois, Urbana, Ill.

Earth Science—William M. Gregory
Normal Training School, Cleveland, Ohio

General Science—Fredric D. Barber
State Normal University, Normal, Ill.

Mathematics—Herbert E. Cobb
Lewis Institute, Chicago

Mathematics Problems—Jasper O. Hassler
Crane Technical High School and Junior College, Chicago

Physics—Willis E. Tower
Englewood High School, Chicago

Physics, Research in—Homer L. Dodge
The State University of Oklahoma, at Norman. Representing American Physical Society

Science Questions—Franklin T. Jones
Warner and Swasey Co., Cleveland, Ohio

Zoology—Worralo Whitney
Hyde Park High School, Chicago

Published Monthly October to June, Inclusive, at Mount Morris, Illinois
Price, $2.50 Per Year; 30 Cents Per Copy

Entered as second-class matter March 1, 1913, at the Post Office at Mount Morris, Illinois, under the Act of March 3, 1879

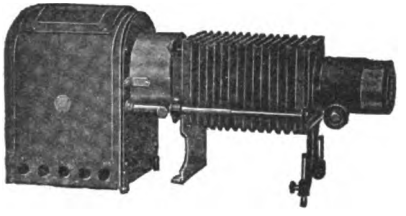
Digitized by Google

"McIntosh Lanterns Are Honest Lanterns."

Lantern Slides of Science

A copy of our Catalogs of science slides was mailed when published to every member of the Central Association. Are you a member? Did you get your copy? Did you keep it?

If not, there is another copy for you if you are interested. Just write us a card and ask for it. No obligation. You'll need it in placing your orders for science slides.



Lanterns from $36.00 up. Opaque and micro projectors, slides and accessories.

McINTOSH STEREOPTICON COMPANY
410 Atlas Block, CHICAGO, ILL.

For Next Semester

Moore and Halligan—PLANT PRODUCTION
—Agronomy and Horticulture

Mayne and Hatch—HIGH SCHOOL AGRICULTURE
—General Treatment

Coulter—PLANT LIFE AND PLANT USES
—Practical Botany—Not too Technical

Hunter—CIVIC BIOLOGY
—Community Welfare

Dryer—HIGH SCHOOL GEOGRAPHY
—Physical—Economic—Regional

Clark—INTRODUCTION TO SCIENCE
—A real general science.

New York
Chicago
Cincinnati
Boston
Atlanta

AMERICAN BOOK COMPANY
330 East Twenty-second Street
CHICAGO, ILLINOIS

Digitized by Google

INDEX TO VOLUME XX, 1920

SCHOOL SCIENCE AND MATHEMATICS

A Journal for All Science and Mathematics Teachers

Founded by C. E. Linneberger

SMITH & TURTON, Publishers

Publication Office, Mount Morris, Illinois

CHICAGO OFFICE, 2059 East 72nd Place, CHICAGO, ILL.

CHARLES H. SMITH
EDITOR
Hyde Park High School, Chicago

CHARLES M. TURTON
BUSINESS MANAGER
Bowen High School, Chicago

DEPARTMENTAL EDITORS

Agriculture—Aretas W. Nolan
The University of Illinois, Urbana, Ill.

Astronomy—George W. Myers
The University of Chicago

Biology, Research in—Homer C. Sampson
The Ohio State University, Columbus

Botany—Worrallo Whitney
Hyde Park High School, Chicago

Chemistry—Frank B. Wade
Shortridge High School, Indianapolis, Ind.

Chemistry, Research in—B. S. Hopkins
The University of Illinois, Urbana, Ill.

Geography—William M. Gregory
Normal Training School, Cleveland, Ohio

General Science—Fredric D. Barber
State Normal University, Normal, Ill.

Mathematics—Herbert E. Cobb
Lewis Institute, Chicago

Mathematics Problems—Joseph A. Nyberg
Hyde Park High School, Chicago

Physics—Willis E. Tower
Englewood High School, Chicago

Physics, Research in—Homer L. Dodge
The State University of Oklahoma, at Norman. Representing American Physical Society

Science Questions—Franklin T. Jones
Warner and Swasey Co., Cleveland, Ohio

Zoology—Harold B. Shinn
Schurz High School, Chicago

Published Monthly October to June, Inclusive, at Mount Morris, Illinois
Price, $2.50 Per Year; 30 Cents Per Copy

Entered as second-class matter March 1, 1913, at the Post Office at Mount Morris, Illinois, under the Act of March 3, 1879

Digitized by Google

Digitized by Google

INDEX BY TITLES

A

Absolute Zero, A Suggestion for Teaching. G. W. WARNER 361
Acceleration Apparatus for Measuring "G" and the Laws of Falling Bodies, Free Fall Machine or. I. THORNTON OSMOND 602
Acoustic Chart, Stansico Correlated. STANDARD SCIENTIFIC COMPANY 746
Acoustical Principles, Some Everyday Applications of. F. R. WATSON 193
Advertising Committee, Report of the, C. A. S. & M. T. GEORGE SYPE 233
Aerial Photography, Mapping by. W. H. SPURGIN 488
Agricultural Organization and Home Project Work. The Educational Basis for Junior. JAS H. GREENE 788
Air Condition in School Buildings. S. R. LEWIS 448
Air Pressure, Common Evidences. STEPHEN S. VISHER 608
Alaska Coal. Increased Output of. U. S. GEOL. SURVEY 173
American Teaching Methods. Assails. ROBERT E. ROSE 868
Aquaria for the School Laboratory, Salt Water. MYRTLE E. JOHNSON 779
Area of the United States, Dimensions and. U. S. GEOL. SURVEY 750
Arizonia. JEHIEL S. DAVIS 57
Articles in Current Periodicals 85, 185, 275, 468, 649, 768, 866
Asphalt in the United States. A Great Undeveloped Resource. U. S. GEOL. SURVEY 576
Association of Teachers of Secondary Mathematics in North Carolina, Meeting of 378
Astronomical Distances, Calculation by Geometry, JOSEPH V. COLLINS 416
Atomic Theory in Baseball Terms. IRVING LANGMUIS 548
Aurora of March 22, 1920, The. LEWIS J. BOSS 487
Automobile in Physics, The. H. C. KRENERICK 197

B

Biology Section, Minutes of the C. A. S. & M. T 238
Biology. Teachers on Recommendations for a New Course of Study for the High Schools of Chicago, Report of. JEROME ISENBARGER 642
Bird Study in the Mississippi Valley. HORACE GUNTHROP 383
Bookkeeping by the Historical Method, Teaching. A. P. R. DRUCKER 70
Book Reviews 96, 188, 278, 374, 472, 560, 656, 770, 866
Book Reviews—
A Handbook of American Private Schools. CHARLES H. SMITH 192
American Red Cross in the Great War. CHARLES H. SMITH 774
Analytic Geometry. HERBERT E. COBB 560
Animal Husbandry. CHARLES H. SMITH 774
An Introductory Course in Quantitative Chemical Analysis. FRANK B. WADE 281
Applied Arithmetic. HERBERT E. COBB 664
Applied Mathematics. HERBERT E. COBB 666
Applied Science for Metal Workers. CHARLES H. SMITH 196
Applied Science for Wood Workers. CHARLES H. SMITH 190
Armenia and the Armenians. CHARLES H. SMITH 656
A Short Course in College Mathematics. HERBERT E. COBB 278
Brightness and Dullness in Children. FRANK N. FREEMAN 474
Cataolgue of Spencer Microscopes. CHARLES H. SMITH 474
College Textbook of Chemistry. FRANK B. WADE 282
Correlated Mathematics for Junior Colleges. HERBERT E. COBB 278
Dietetics for High Schools. CHARLES H. SMITH .....
Div-a-let. HERBERT E. COBB 278
Elementary Biology, An Introduction to the Science of Life. WORRELO WHITNEY 280
Elements of Victor Algebra. HERBERT E. COBB 666

Digitized by Google

Engineering Application of Higher Mathematics. CHARLES H. SMITH 192
Everyday Chemistry. HERBERT R. SMITH 561
Every Step in Canning. CHARLES H. SMITH 474
Examples in Magnetism. CHARLES H. SMITH 192
Exercises in Chemistry. FRANK B. WADE 283
Experimental Organic Chemistry. FRANK B. WADE 660
Fundamentals of High School Mathematics. HERBERT E. COBB 558
General Botany. HENRY S. CONRAD 558
General Mathematics. HERBERT E. COBB 374
Household Arithmetic. HERBERT E. COBB 664
Infinitesimal Calculus. HERBERT E. COBB 666
Intermediate Text Book of Chemistry. FRANK B. WADE 376
Introduction to Vocational Education. CHARLES H. SMITH 772
Laboratory Manual of Elementary Colloid Chemistry. FRANK B. WADE 660
Lighting from Concealed Sources. CHARLES H. SMITH 866
Modern Junior Mathematics. HERBERT E. COBB 375
Number by Development. HERBERT E. COBB 278
Number by Development Vol. III Grammar Grades. HERBERT E. COBB 664
Plane Geometry. HERBERT E. COBB 376
Plane Trigonometry for Secondary Schools. HERBERT E. COBB 666
Plant Production. WORROLO WHITNEY 280
Practical Physics. CHARLES H. SMITH 774
Principal of Agriculture for High Schools. CHARLES H. SMITH 192
Psychology from the Standpoint of a Behaviorist. CHARLES H. SMITH 472
Qualitative Analysis. FRANK B. WADE 96
Second Course in Algebra. HERBERT E. COBB 664
South. CHARLES H. SMITH 772
Teaching Home Economics. CHARLES H. SMITH 190
The Blind, Their Condition and the Work Being Done for Them in the United States. CHARLES H. SMITH 188
The Elements of Physics. CHARLES H. SMITH 772
The High School Boy and His Problems. CHARLES H. SMITH 662
Vocational Agricultural Education by Home Projects. WORROLO WHITNEY 280
What Will Metric Standardization Cost? CHARLES H. SMITH 662
Zoology, a Textbook for Colleges and Universities. HAROLD B. SHRINE 657
Books Received 96, 187, 277, 470, 559, 654
Botany, Introductory Courses in. BRADLEY M. DAVIS 52, 352, 692
Brocard Points, Determination of the. J. CARL KAMPLAIN 51

C

Cadmium in 1919, Production of. U. S. GEOL. SURVEY 391
Cajoris History of Mathematics, Second List of Marginal Notes on. G. A. MILLER 300
California Science and Mathematics Association, Southern. N. D. KNUPP 558
Central Association of Science and Mathematics Teachers, Minutes of the 1919 Annual Meeting of the. HARRY O. GILLET 232
Central Association of Science and Mathematics Teachers, 1920 Officers of the 184
Chain Hoist, The Differential Pulley or. W. F. ROECKER 142
Charts for Prose Problems, The Use of. JOS. A. NYBERG 619
Chemical Nomenclature and Pronunciation. J. NORMAN TAYLOR 850
Chemical Warfare Service and Chemical Teaching. WILLIAM MCPHERSON 200
Chemistry, A High School Course in Trade. EDWIN G. PIERCE 27
Chemistry for Girls, The Outline of a Course in Practical. CHARLES E. DULL 841

Digitized by Google

Chemistry, Research in. B. S. HOPKINS....392, 501, 571, 673
Chemistry Section, Minutes of the C. A. S. & M. T. HARRY M. MESS 240
Chemistry Teacher Know, What Should the. FRANK B. WADE.... 403
Clark Agency, Minnesota Superintendent to Manage.... 363
Classroom Activities in Science, Outside. L. C. FELDMAN.... 700
Class Room Sayings....269, 256, 747
Coal Industry, Bituminous. U. S. GEOL. SURVEY.... 461
Coal Mining in Alaska. U. S. GEOL. SURVEY.... 565
College Entrance Examination Board Questions in Chemistry. HENRY L. GERRY.... 845
College Mathematics, Freshman. E. E. WATSON.... 531
Color Blindness, Test for. MAUD S. STUART.... 553
Commercial Education, A Survey Report of. SCHOOL REVIEW.... 182
Commercial Geography as Vocational Guidance. ANDERW NICHOLS 706
Copper, Alaska Produces 70 Million Pounds of. U. S. GEOL. SURVEY 150
Cubic Equations by Straight Line Graphs, Solution of. M. G. SCHUCKER.... 818

D

Decay of Mountains and Formation of Soils, The. LYMAN C. WOOSTER 792
Desk With a Vertical Filing System for Showing Apparatus, A Portable Science Demonstration. CHARLES W. FINLEY and EARL R. GLENN.... 782
Determinants, A Study of. C. M. HIMEL and C. A. STONE.... 855
Development of Mathematical Ideas, Numerically and Geometrically The Parallel. LOUIS C. KARPINSKI.... 821
Differential Pulley or Chain Hoist, The. W. F. ROECKER.... 142
Diffraction Grating, Hilger. ADAM HILGER & CO.... 762
Directory of Science and Mathematics Societies....284, 566, 668
Discipline of Expression, The. MAX J. HERZBERG.... 697
Dismal Swamp of Virginia and North Carolina, The. U. S. GEOL. SURVEY.... 437
Distance Problems, Time Rate and. JOS. A. NYBERG.... 539

E

Earth Science in the Reorganized High School, Report of the Committee on. JAMES H. SMITH.... 256
Editorial Notice.... 272
Educational Function and Valve, Classification of School Subjects Based on. LYMAN C. WOOSTER.... 550
Educational Notes. GINN AND COMPANY.... 186
Einstein's Theory of Gravitation from the Standpoint of the Teacher of Physics. DR. JOSEPH S. AMES.... 477
Electron and the Building of Atoms, The Positive. WILLIAM D. HASKINS....392, 501
Electron in Elementary Physics, The Use of the. DANIEL L. RICH.... 220
Engineering and Science in Shipbuilding, The Application of. GEORGE D. ROALFE.... 801
English Expression in its Relation to Teaching of Science. R. R. SMITH.... 341
English in Science Courses, The Use of. E. H. JOHNSON.... 14
Examinations and Tests, A Study of. MABEL W. ARLEIGH.... 629
Excursions, Report on C. A. S. & M. T.... 237

F

Federal Aid to Soldiers. PUBLIC HEALTH SERVICE.... 326
Field Trips, Notes on Managing. ELLIS C. PERSING.... 797
Florida Freeze on Insects, Effect of a MONTHLY WEATHER REVIEW.. 758
Ford Educational Library.... 852
Fundamentals in Method—Old and New. CHARLES J. PIEFER.... 409

G

Gage, A New Direct Reading Vacuum. W. H. FARR.... 495

Digitized by Google

Gasoline from Natural Gas. U. S. Geol. Survey 19
General Science and the Teacher Training it Involves, The Rôle of Laboratory Work in. Herbert Brownell 317
General Science and Vocational Education. A. W. Nolan 454
General Science, A Textbook for. Neil E. Gordon 419
General Science in the High School, The Place of. John Calvin Hanna 516
General Science of the Future, The. G. M. Ruch 423
General Science, Possibilities of Home Work in. G. A. Bowden 327
General Science Section, Minutes of the C. A. S. & M. T. Ada L. Weckel 257
General Science, Some Tangible Results from a Course in. George Mounce 632
Geography as a Fundamental High School Subject, Steps Necessary to Establish. F. E. Williams 347
Geography as a Means of Improving its Teaching, Conservative Work in. Alison E. Aitchison 499
Geography in the High School, Scope of. John Calvin Hanna 214
Geography Section, Minutes of the C. A. S. & M. T. Anne B. Roystton 251
Geography, Some Important Phases of. Fred K. Branom 157
Geography Teachers, Aims of Modern. E. E. Lackey 872
Geology and War. U. S. Geol. Survey 876
Geometric Recreation, A. Isabel Harris 731
Good Yeast, How to Tell. Leonard K. Hirshberg 820
Group Tests, Formula for. Harold S. Hulbert 147

H

Higher Salaries for Teachers, A Plea for. Chicago High School Teacher Club 141
High School Course in Chemistry Meet the Demands of Vocational Chemistry? How Does the Present. Frank B. Wade 313
High School Course of Study and Methods of Teaching Mathematics, Some Factors Affecting the Selection of the. H. R. Douglas 287
High School Geography? What Changes Should be Made in Our Methods of Teaching. W. R. McConnell 117
High School Physics, A Project in Electricity for. Hiram W. Edwards 459
High School Science, The Reorganization of. George R. Twiss 1
Highway and Highway Transport Education Conference. U. S. Com. of Education 644
History of Mathematical Ignorance, Value of the. G. A. Miller 813
Hollow Building Tile Growing in Favor 33
Holy Land, The. F. Renwick 143
Home Economics Section, Minutes of the C. A. S. & M. T. Sybil Woodruff 261

I

Industrial Art Schools 742
Intelligence Testing in the Department of Physics, University of Chicago, Preliminary. Harvey B. Lemon 226
Intelligence Tests, Development of Group 91

J

Junior High School Mathematics, Up-to-Date Problems in. Theodore Lindquest 305

L

Laboratory Work in General Science and the Teacher Training It Involves, The Rôle of. Herbert Brownell 317
Laboratory Work, Variety is the Spice of. C. C. Leeson 752
Lake Tahoe Has Shrunken. U. S. Geol. Survey 750
Langmuis Receives Nichols Medal. Dr. Irving 564

Digitized by Google

Light for Retouching. PHOTO-ERA 391
Logarithms and Slide Roles, Talk on. FLORIAN CAJORI 527
Logarithms and the Slide Role in the Ninth Grade, The Teaching of. C. EBEN STROMQUIST 624

M

Manufacturers Desire the Metric System, American. WORLD TRADE CLUB 33
Mapping by Aerial-Photography. W. H. SPURGIN 488
Mathematics as a Factor in Education, The Claims of. C. N. MOORE 438
Mathematics for High School, Applied. EUGENE H. BARKER ....
Mathematics, Freshman College. E. E. WATSON 531
Mathematics of Elementary Physics, The. PHILO F. HAMMOND 714
Mathematics Section, Minutes of the C. A. S. & M. T. ELSIE G. PARKER 264
Mathematics, Some Factors Affecting the Selection of the High School Course of Study and Methods of Teaching of. H. R. DOUGLAS 287
Mathematical Subjects, Correlation of. E. R. BRESLICH 125
Mathematics Teachers, The National Council of. ALFRED DAVIS 382
Mathematics, Up-to-Date Problems in Junior High School. THEODORE LINDQUEST 305
Math. Quest, The. HELEN WHITAKER 457
Membership Committee, Report of the C. A. S. & M. T. CHARLES S. WINSLOW 233
Metric Standardization Easy; Not Expensive, Large Steel Manufacturer Declares. WORLD TRADE CLUB 182
Metric Standardization, Ninety-Nine Per Cent Favor. WORLD TRADE CLUB 156
Metric Systems, School Children Demand. WORLD TRADE CLUB 13
Metric Units—Advertising Men Need. WORLD TRADE CLUB 65
Molecular Motion, Illustration of. J. NORMAN TAYLOR 514
Monkey Stops Climbing, The. WILLIAM F. RIGGE 172

N

National Academy of Sciences 363
National Committee on Mathematical Problems, Notes and News Concerning the Work of, The. J. W. YOUNG 92, 754, 764
National Committee on Mathematical Requirements, The 476
National Research Council. CARNEGIE CORPORATION 312, 362
Natural Gas, Gasoline from. U. S. GEOL. SURVEY 19
Nature Study in the Elementary School Curriculum, The Place of. S. H. WILLIAMS 838
Negatives, A Note on. FRANK H. MCMACKIN 640
Nitrogen, Activated. L. V. ANDEREGG 571
Nitrogen, The Disintegration of. R. W. MILLER 512

O

Oil Drilling in Alaska. U. S. GEOL. SURVEY 100
Oil Industry, Government in Touch With. U. S. GEOL. SURVEY 181
Oil Wells in South Central Arkansas, Promising. U. S. GEOL. SURVEY 696

P

Pascal's "New Experiments on Vacuum." WILLARD J. FISHER 723
Passive State; A Review of the Theories, The. J. N. REEDY 673
Peat, Uses of. U. S. GEOL. SURVEY 876
Pedagogy, The New 874
Phosphate Rock, Large Production of 364
Physical Equipment of the School Building in Classroom Instruction, The Use of. DEAN E. S. KEENE 577
Physical Tests. MARION D. WESTON 577
Physics, Research in. HOMER L. DODGE 477, 681
Physics Section, Minutes of the C. A. S. & M. T. A. W. AUGER 266

Digitized by Google

Physics Teacher Know? What Should the. C. L. VESTAL 151
Physics Test. C. P. FINGER 472
Physiology in Our Schools. W. E. NELSON 166
Plant Protection Institute. NATIONAL RESEARCH COUNCIL 749
Platinum from Alaska. U. S. GEOL. SURVEY 134
Plus and Minus Signs in Algebra. Jos. A. NYBERG 435
Potash Deposits in Germany, The Great. U. S. GEOL. SURVEY 494
Potash Deposits in Spain. U. S. GEOL. SURVEY 515
Potash Deposits of Alsace, The. U. S. GEOL. SURVEY 641
Pottery Industry in 1918, The. U. S. GEOL. SURVEY 91
Pricer in His Relation to Natural Science. John Larsen. H. J. VAN CLEVE 652
Problem and its Numerical Solution, A. W. W. SLEATER 612
Problem Department. J. O. HASSLER 86, 174, 270
Problem Department. J. A. NYBERG 365, 465, 554, 637, 743, 854
Problems for the Classroom from the Orientation Work of the A. E. F., Some. C. A. EPPERSON 210
Problems of Algebra, Prose. Jos. A. NYBERG 829
Project as a Method of Teaching, The. ROLLAND M. STEWART 594
Project as a Teaching Method, The. R. W. SHARPE 20
Project in Electricity for High School Physics. HIRAM W. EDWARDS 459
Project Method in High School Mathematics, Some Applications of the. EDITH ST. JOHN EATON 443
Project in Science Teaching, Utilization of the Chance. FRANK B. WADE 775
Projects in High School Mathematics, A Few Live. FRANK M. RICH 34
Publishers Announcement 209, 365

Q

Quadratic Equation, The Character of the Roots, of a. ROBERT E. MORITZ 433
Quick Silver in 1918. U. S. GEOL. SURVEY 84
Quick Silver Produced in the United States. U. S. GEOL. SURVEY 636

R

Radio-Waves, The Production of Damped. WILLIAM SCHRIEVER 681
Railway and Steamship Maps, Report of the Committee on C. A. S. & M. T. J. PAUL GOODE 234
Range of Information Test in Science Revised, The. ELLIOT R. DOWNING 77
Rate and Distance Problems, Time. Jos. A. NYBERG 539
Red Cross—Why the Colleges Should Support the Red Cross. AMERICAN 870
Relation Between the Three Sides of a Right Triangle, Some Interesting Facts Concerning the. ROBERT R. KNOWLES 562
Reorganization of High School Science, The. GEORGE R. TWISS 1
Roots of a Quadratic Equation, The Character of the. ROBERT E. MORITZ 433

S

San Diego, California, Water Supply for. U. S. GEOL. SURVEY 112
School Bonds at Tulsa, Okla., Issue 312
School Subjects Based on Educational Function, and Value, Classification of. LYMAN C. WOOSTER 550
Science and Humanism. LYNN HAROLD HOUGH 97
Science Instruction in Secondary Schools, Present Needs of. ROBERT A. MILLIKAN 101
Science Questions. FRANKLIN T. JONES 92, 177, 273, 368, 556, 646, 858
Singing Tube, A Convenient Form of the New. CHARLES T. KNIPP 787
Slide Rules, Talk on Logarithms and. FLORIAN CAJORI 527
Spherical Triangles, The Graphical Solution of. MYRON O. TRIPP 734
Such is Life. ELEANOR J. OLMSTEAD 135

Digitized by Google

Summer Resorts in Southwestern Maine, Maps of. U. S. Geol. Survey 750
Snowstorm in Palestine, February, 1920, Tremendous. Otis A. Glazebrook 760
Sunset-Midway Oil District of California, Government Report on the. 564
Surveys, West Indian. U. S. Geol. Survey 139

T

Talc and Soapstone Industry. U. S. Geol. Survey 442
Teachers Suffer Most. Industrial Conference 549
Teacher Teach, Helping the. U. S. Dept. of Agriculture 26
Teaching Method, The Project As a. R. W. Sharpe 20
Teaching of Geography and the World War, The. H. E. Branom 758
Teaching of Science and Mathematics, The Relations of Vocational Guidance of Our. Anna Y. Reed 105
Teaching of Science, English Expression in its Relation to. R. R. Smith 341
Teaching the Absolute Zero, A Suggestion for. G. W. Warner 361
Test in Science Revised, The Range of Information. Elliot R. Downing 77
Tests in Science, Standardized. Ralph E. Wager 66
Theorem of Nicomachus, The. Oscar Schmiedel 462
(Thermionic) X-Ray Tube, The Coolidge. Homer L. Dodge 337
Time, Rate and Distance Problems. Jos. A. Nyberg 539
Tin, Alaska Produces. U. S. Geol. Survey 124
Top Reviewed, An Old Form of. Charles T. Knipp 113
Treasurer, Report of the C. A. S. & M. T. John H. McClellen 236
Tuning Forks, A New Method of Rating. F. Renwick 143

U

University of Michigan Summer School for Biology 572

V

Vacuum Gage, A New Direct Reading. W. H. Farr 495
Visual Education, The Scope and Outlook of. J. Paul Goode 482
Vocational Chemistry, How Does the Present High School Course in Chemistry Meet the Demands of. Frank B. Wade 313
Vocational Education, General Science and. A. W. Nolan 454
Vocational Guidance to Our Teaching of Science and Mathematics, The Relation of. Anna Y. Reed 105

W

Water Wheels Manufactured in the United States, Shipments in 1918 of. U. S. Geol. Survey 84
Water Power in Southeastern Alaska. U. S. Geol. Survey 181
Weather Prophets, Animal. Scientific American 748
Weight of Data. J. P. Ballantine 140

X

X-Ray Tube, The Coolidge (Thermionic). Homer L. Dodge 337

Z

Zero and Unity, Some Applications of the Various Forms of. Richard Morris 544

Digitized by Google

Digitized by Google

INDEX BY AUTHORS

A

AITCHISON, ALISON E., Cedar Falls, Ia. 499
AMES, JOSEPH S., Johns Hopkins University 477
ANDEREGG, L. O., Purdue University 571
ANNING, NORMAN, Orono, Maine 271, 366, 367, 465, 467, 639
ARLEIGH, MABEL W., South Pasadena, Calif. 629
AUGER, A. W., Tilden High School, Chicago 266

B

BAILEY, WILLIAM, Dickinson High School, Newark, N. J. 175
BALLANTINE, J. P., The University of Maine 140
BARKER, EUGENE H., Polytechnic High School, Los Angeles 46
BAROTZ, N., New York City 86, 270, 554, 555
BOSS, LEWIS J., Popular Astronomy 487
BOREMAN, ROBT. W., School of Technology, Atlanta, Ga. 179
BOWDEN, G. A., University School, Cincinnati 327
BRANOM, FRED K., Chicago Normal College 157
BRANOM, H. E., Harris Teacher College, St. Louis 758
BRESLICH, E. R., School of Education, The University of Chicago 125
BROWN, THOS. G., Boys' Technical High School, Milwaukee, Wis 466
BROWN, WILLIAM H., High School, Amherst, Mass. 270
BROWNELL, HERBERT, University of Nebraska, Lincoln 317
BUREAU OF EDUCATION 644

C

CAJORI, FLORIAN, University of California 527
CARNEGIE CORPORATION, New York City 312
CARTER, W. S., Chief Supt. of Education, Fredericton, New Brunswick 273
CLARK AGENCY, Chicago 363
COBB, HERBERT E., Lewis Institute, Chicago 278, 374, 375, 376, 560, 664, 666
COLLINS, JOSEPH V., Normal School, Stevens Point, Wis. 416
CONRAD, HENRY S. 558
CORRECTIONS 45
CORZINE, H. W., Cleveland, Ohio 558

D

DAVIS, ALFRED, Soldan High School, St. Louis 382
DAVIS, BRADLEY M., University of Michigan 52, 352, 692
DAVIS, JEHIEL S., Prescott, Arizona 57
DEPARTMENT OF THE INTERIOR 84, 181
DODGE, HOMER L., University of Oklahoma 337, 681
DONOVAN, HAROLD G., High School, Concord, N. H. 554, 638
DOUGLAS, H. R., University of Oregon 287
DOWNING, DR. ELLIOTT R., University of Chicago 77
DRUCKER, A. P. R., Colorado State College, Colorado Springs 70
DULL, CHARLES E., South Side High School, Newark 841

E

EATON, EDITH ST. JOHN, Berkeley, Calif. 443
EATON, T. E. N., High School, Redlands, Calif. 367
EPPERSON, C. A., Teachers College, Kirksville, Mo. 210

F

FARR, W. H., Central Scientific Co., Chicago 144, 495
FELDMANN, L. C., High School, Oshkosh, Wis. 700
FINGER, C. P., Ferndale, Calif., Union School 472
FINLEY, CHAS. W., Lincoln School, Teachers College, Columbia Univ. 782
FISHER, WILLARD J., Woods Hole, Mass. 723
FREEMAN, FRANK N., University of Chicago 475

Digitized by Google

G

GERRY, HENRY L. Worcester, Mass., Academy 845
GILLET, HARRY O., The University of Chicago 232
GINN & Co., Boston, Mass 186
GLAZEBROOK, OTIS A., Jerusalem, Palestine 760
GLENN, EARL R., Lincoln School, Teachers College, Columbia Univ. 782
GOODE, J. PAUL, University of Chicago 234, 482
GORDON, NEIL E., Maryland State College, College Parks 419
GRAHAM, MARIA D., North Carolina College for Women, Greensboro 378
GREENE, JAS. H., University of Illinois 788
GUNTHROP, HORACE, Washburn College, Topeka, Kan 383

H

HAMMOND, PHILO F., University of Wyoming 714
HANNA, JOHN CALVIN, State Supervisor of High Schools, Springfield, Ill 241, 516
HARKIN, WILLIAM D., University of Chicago 392, 501
HARRINGTON, HELENA M., Saint Clara College, Sinsinawa, Wis 366
HARRIS, ISABEL, Richmond, Va 731
HASSLER, J. O., Crane Junior College, Chicago 86, 175, 270
HERZBERG, MAX J., Central High School, Newark 697
HILGER, ADAM, London, Eng 762
HINSEL, C. M., High School, Des Plaines, Ill 835
HIRSHBERG, LEONARD K 820
HOPKINS, B. S., University of Illinois 392, 571, 673
HOUGH, LYNN HAROLD, President Northwestern University 97
HULBERT, HAROLD S., U. S. Navy 147

I

ISENBORGER, JEROME, Lake View High School, Chicago 642

J

JAMES, CLARKE, High School, San Jose, Calif 744
JOHNSON, E. H., Kenyon College, Gambier, Ohio 14
JOHNSON, MYRTLE E., High School, Pasadena 779
JONES, FRANKLIN T., Warner and Swasey Co., Cleveland 92, 177, 273, 368, 556, 646, 858
JONES, HAZEL C., Danville, Ill 174

K

KAMPLAIN, J. CARL, Crane Junior College, Chicago 51, 175
KARPINSKI, LOUIS C., University of Michigan 821
KEENE, DEAN E. S., School of Mechanic Arts, Fargo, N. D 583
KNIPP, CHARLES T., University of Illinois 113, 787
KNOWLES, ROBERT R., High School, Sterling, Col 562
KNUPP, N. D., Santa Monica High School, California 558
KRENERICK, H. C., North Division High School, Milwaukee, Wis 197

L

LACKEY, E. E., Normal School, Wayne, Neb 872
LEESON, C. C., Teachers College, Maryville, Mo 752
LEMON, HARVEY B., The University of Chicago 226
LEWIS, S. R., Chicago, Ill 448
LINDQUEST, THEODORE, Normal School, Emporia, Kansas 305

M

MACK, F. D., La Crosse, Wis 275
MALONE, W. L., Tacoma, Washington 275
MCCLELLAN, JOHN H., Harrison High School, Chicago 236
MCCONNELL, W. R., Miami University, Oxford, Ohio 117
MCCOY, WILLIAM T., Phillips High School, Chicago 141
MCGREGOR, R. T., Elk Grove, Col 87, 271
MCMACKIN, FRANK H., Dickinson High School, Newark 640

Digitized by Google

McPherson, William, Ohio State University 200
Mess, Harry M., Senn High School, Chicago 240
Millar, R. W., University of Illinois 512
Miller, G. A., University of Illinois 300, 813
Millikan, Robert A., The University of Chicago 101
Monthly Weather Review, Washington 758, 760
Moore, C. N., University of Cincinnati 438
Moritz, Robert E., University of Washington, Seattle 433
Morris, Richard, Rutgers College 544
Mounce, George, High School, LaSalle, Ill 632

N

National Academy of Sciences, Washington, D. C 363
National Research Council, Washington, D. C 362, 749
Nelson, W. E., Sabetha, Kan 166
Nichols, Andrew, Austin High School, Chicago 706
Nolan, A. W., University of Illinois 454
Nyberg, Jos. A., Hyde Park High School, Chicago 365, 435, 465, 539, 554, 619, 637, 743, 829, 854

O

Olmstead, Eleanor J., High School, Antigo, Wis 135
Osmond, I. Thornton, State College, Penn 602

P

Packard, J. C., Brookline, Mass 558
Packham, Jas. H., Collegiate Institute, Owen Sound, Ga. 555, 638, 743
Pagelow, Wm. A., Dickinson High School, Newark 638
Pandya, N. P., Amreli, India 90
Parker, Elsie G., Oak Park High School, Oak Park, Ill 264
Pelletier, G., Ecole Polytechnique, Montreal, Can 86, 87, 88, 175, 176, 271, 466, 554, 639, 743, 744
Persing, Ellis C., Glenville High School, Cleveland 797
Photo-Era, Boston, Mass 391
Piefer, Charles J., University High School, Chicago 409
Pierce, Edwin G., East Technical High School, Cleveland 27
Public Health Service 326

R

Reed, Anna Y., United States Employment Service, Washington, D. C 105
Reedy, J. H., University of Illinois 673
Renwick, F. 143
Rich, Daniel L., University of Michigan 220
Rich, Frank M., School 19, Paterson, N. J 34
Rigge, William F., Creighton University, Omaha, Neb 172
Roalfe, George D., Los Angeles, Calif 801
Roecker, W. F., Technical High School, Milwaukee, Wis 142
Roray, Nelson L., Metuchen, N. J 175, 554, 638
Rose, Robert E., Wilmington, Del 868
Royston, Anne B., Hyde Park High School, Chicago 251
Ruch, G. M., University of Oregon, Eugene 423

S

Schmiedel, Oscar, Parsons College, Fairfield, Iowa 462
School Review, University of Chicago Press 182
Schriever, William, University of Oklahoma 681
Schucker, M. G., Peabody High School, Pittsburgh, Pa., 86, 365, 637, 818
Scientific American, New York City 748
Sharpe, R. W., DeWitt Clinton High School, New York City 20
Shinn, H. B., Schurz High School, Chicago 656
Sklar, Louis, Drexel Institute, Philadelphia 86, 743

Digitized by Google

SMITH, CHARLES H., Hyde Park High School, Chicago
85, 96, 184, 185, 187, 188, 190, 192, 269, 272, 275, 278, 284, 456, 468, 470, 472, 474, 559, 566, 649, 654, 656, 662, 668, 747, 768, 770, 772, 774, 866
SMITH, H. R., Lake View High School, Chicago 561
SMITH, JAMES H., Austin High School, Chicago 256
SMITH, R. R., School of Engineering, Milwaukee 341
SPURGIN, W. H., Hyde Park High School, Chicago 488
STEATER, W. W., University of Michigan 612
STEWART, ROLLAND M., Cornell University 594
STONE, C. A., High School, Des Plaines, Ill 855
STROMQUIST, C. EBEN, University of Wyoming 624
STUART, MAUD S., Faribault, Minn 553
SYPE, GEORGE H., Austin High School, Chicago 233

T

TAYLOR, J. NORMAN, Washington Preparatory School, D. C. 514, 850
THOMAS E. N., Eaton High School, Redlands, Cal 745
TRIPP, MYRON O., University of Maine 734
TWISS, GEORGE R., Ohio State University 1

U

U. S. DEPT. OF AGRICULTURE 26
U. S. GEOL. SURVEY
19, 26, 33, 51, 84, 91, 100, 112, 134, 139, 150, 173, 181, 196, 364 391, 437, 442, 494, 515, 564, 565, 576, 636, 641, 696, 733, 748, 750 876

V

VAN CLEAVE, H. J., University of Illinois 652
VESTAL, C. L., Schurz High School, Chicago 151
VISHER, STEPHEN S., Indiana University 608

W

WADE, FRANK B., Shortridge High School, Indianapolis
282, 313, 377, 403, 660, 775
WAGER, RALPH E., Normal School, DeKalb, Ill 66
WARNE, WALTER R., State College, Penn 270, 465, 554, 637, 744
WARNER, G. W., Englewood High School, Chicago 361
WATSON, E. E., Parsons College, Ia 531
WATSON, F. R., The University of Illinois 193
WECKEL, ADA L., Oak Park High School, Oak Park, Ill 257
WESTON, MARION D., Rhode College of Education 577
WHITAKER, HELEN, Topeka, Kansas 457
WHITAKER, HERBERT C., Philadelphia, Pa 270, 271, 744
WHITNEY, WARROLO, Hyde Park High School, Chicago 280
WILLIAMS, F. E., University of Wisconsin 347
WILLIAMS, S. H., Normal School, Slippery Rock, Penn 838
WINSLOW, CHARLES S., Senn High School, Chicago 233
WOODRUFF, SYBIL 261
WOOSTER, LYMAN C., Normal School, Emporia, Kansas 550, 792
WORLD TRADE CLUB, San Francisco, Calif 13, 33, 65, 156, 182, 364

Y

YOUNG, J. W., Dartmouth College 476, 754, 764

Digitized by Google

Digitized by Google

Digitized by Google

SCHOOL SCIENCE AND MATHEMATICS

VOL. XX, No. 1 JANUARY, 1920 WHOLE No. 165

THE REORGANIZATION OF HIGH SCHOOL SCIENCE[1].

BY GEORGE R. TWISS,

Ohio State University, Columbus, Ohio.

I am deeply sensible of the honor that has been accorded me through the invitation to address this body on a subject which in my judgment is of vital importance to the nation. However, I feel that the ideas that I might bring to the discussion of the reorganization and improvement of science instruction from the individual and local standpoint would, in large degree be coals brought to Newcastle because this association has kept itself closely in touch with the reorganization movement from the beginning, and has been one of the most important factors in starting the campaign for reorganization and carrying it forward from its inception to the present time. In proof of this I need only to recall the work in 1909-10 of members of this association in the committees on biology, earth science, physics, and chemistry of the North Central Association of Colleges and Secondary Schools, which helped revolutionize the point of view on the aims and methods of science teaching throughout the North Central territory and which helped to loosen up the requirements in science of the College Entrance Board of the Middle States and Maryland—to the far reaching influence of Dr. Mann through his work in organizing the National Commission on the Teaching of Physics, and in the country-wide study of methods and educational opinion that was carried on under his chairmanship—to the propaganda work carried on for more and better biology teaching by Caldwell, Galloway, Downing, Eichenbury and others—to the numerous studies and experiments made by members of this association and directed toward methods of teaching earth science and chemistry with closer regard to the pupils' interests and needs—to the

[1]Read at the evening meeting of the Central Association of Science and Mathematics Teachers at Lake View High School, Chicago, Friday, November 28, 1919.

Digitized by Google

cordial cooperation and enthusiastic support given the Kingsley Commission on the Reorganization of Secondary Education, which in fact owes its existence not a little to some of the leaders in this body—and finally to the great work done by your official organ, SCHOOL SCIENCE AND MATHEMATICS in furnishing an outlet through which the leavening influence of all this activity has been spread. If all this were not sufficient I might refer to the important contributions made by members of this association in the form of text books in science for high schools, and of books and articles on the teaching of science, which have pointed out the way to a wiser choice of subject matter and better methods of teaching. Yet while all this crystallization of opinion has gone forward amongst us, and while many of your individual members have been successfully working out one or another of the principles of reorganization on which you have from time to time agreed, it is somewhat discouraging to those of us who are constantly in touch with educational work through field observation, that this leavening process has been so slow in modifying the actual practice of the great majority of science teachers. Those who attend these meetings, who read SCHOOL SCIENCE AND MATHEMATICS, and the *General Science Quarterly*, and keep up with the new books and papers on science teaching which are coming out from time to time would be surprised to find out how few science teachers have caught the new spirit, and how few the schools are in which science is really being reorganized or changed in any way from the subject matter and methods of twenty years ago. Unfortunately those who come here are not typical of the whole body of science teachers in the states from which they come.

The ratio of the number of science teachers with modern insight and ideals to the number of those who are conducting merely book recitations and formal laboratory practice is probably not much greater than the ratio of the number of attendants at such meetings as this to the number who stay at home, or not much greater than the ratio of the number of subscribers to SCHOOL SCIENCE AND MATHEMATICS to non-subscribers. This ratio as you all know is very small. We have progressed well in formulating principles for a better educational practice in science teaching; but we have done very, very little toward getting our improved ideas across to the great mass of science teachers, and inducing them to use these principles in the control of their classroom and laboratory methods. The problem

Digitized by Google

has got to the point where the greatest need lies in educational statesmanship and organized propaganda.

When we entered the great war for freedom and democracy we were brought face to face with a great and pressing need for scientific knowledge, for scientific methods of solving new problems, for the material products of applied science, and for scientific practices in speeding up production, in amounts and degrees beyond anything that ever had been thought possible or even dreamed of before the need developed.

In the general staff, in the naval and military forces, and in the industries back of them, we needed an army of trained scientists. In our colleges and high schools, in our industrial laboratories and in our government departments we had but a regiment or two, but these, scenting the battle from afar, rose up almost as one man. They quickly mobilized themselves for action and volunteered to meet their country's need. With splendid ability and devotion they organized for work, and sacrificed themselves without stint or thought of reward. Again and again they accomplished the impossible, through organized research and organized intensive training. In cooperation with the scientists of England, France and Italy not only did they make it possible to bring the war to a swift and victorious conclusion, but they gave our people a convincing demonstration of the miracles of production that can be wrought by men trained in the methods of science when working in a compact and harmonious organization, and generously provided with funds.

A year has passed since the day of victory; and we have had time to sense the havoc that a power-drunk and money-mad nation of imperialists has wrought. For four years, millions of workers have been withdrawm from production. They have been employed in destroying one another and wiping out the material accumulations of generations and even centuries of peaceful industry, of art and of science. Civilization has been disorganized and shaken to its foundations. Strong nations are facing bankruptcy, and the menacing shadow of starvation overhangs millions of people. Strikes and violence are brewing everywhere.

In their ignorance of what the most elementary schooling in natural science and economics would have made plain to them as an open book, armies of organized workers are clogging the wheels of industry. They are slowing down production and paralyzing transportation in the face of a world scarcity of prac-

Digitized by Google

tically every product of labor that is necessary to life, while still other armies of unorganized consumers, reacting from war time self denial have plunged into an orgy of wastefulness and extravagance. *Down that road lies anarchy*, and there is only one way out. We must economize, conserve, stop waste, cut out extravagance, idleness and inefficiency of every sort and speed up the production and transportation and equitable distribution of everything that is really needed in the peaceful enjoyment of individual and collective life.

To meet this new and sinister emergency it is as plain as daylight that we need even higher and nobler types of patriotism and morality than we needed in war time. We need sincere and devoted preachers and moralists and statesmen—yes,—but we need organized scientific research and direction, and reorganized universal scientific instruction still more; for without these no efforts of moralists and statesmen can avail. If there isn't enough food and clothing and shelter to go around, the strong will take it from the weak and no preaching or moralizing or passing of laws can stop them.

These problems cannot be solved in a day nor in a year. Scientific organization and leadership we must have, to weather the storm that is upon us; but to hold the heritage of the past and build on it a better and higher civilization to which we look forward, we must have more scientific leaders. We must have more of generous and open handed support for scientific investigation, and above all more of intelligent appreciation by our whole people of the value and the need of scientific research on a scale commensurate with the greatness of our national resources and the extent and urgency of our national needs.

We must enter on a program of preparedness which shall build up an army of scientific workers to supply future needs. Not a whit less also do we need an army of trained science teachers and supervisors to rear a generation of scientifically minded laymen who shall stand as an intelligent and appreciative constituency behind this army of scientists and give them the moral and financial support that is absolutely essential to their success. The people, who hold the purse strings, who vote the taxes, and who through their representative control the state and national governments, and the universities, experiment stations, and industrial laboratories, must be made to understand; and they cannot understand so long as the language of science remains for them a foreign language, and so long as the methods of science remain hidden from them by a cloud of mystery.

Digitized by Google

So it appears that the most important problem in the reorganization of science teaching at this time is more a national problem of educational organization and administration than an individual problem of improved methods.

We must initiate a movement that will eventuate in putting all our people in possession of the most essential elementary facts of science and giving them some understanding of the value of research and the necessity of applying the scientific method to the solution of our national, state, and community problems, both urban and rural. This must be done through the education of the children in our schools. You can do almost what you will with a nation if you can control the subject matters and processes of instruction by means of which the minds of its children are directed and formed. Germany has given us a most convincing example of what can be done by organized instruction, in rearing a generation that will render unthinking obedience to a conscienceless imperialistic autocracy. We must profit by this example of autocratic thoroughness and efficiency in the accomplishment of evil ends, and turn it to account by devising methods equally thorough and efficient, but democratic and enlightened, for the accomplishment of good ends.

Therefore it seems plain that we must reorganize our school systems so as to give some scientific instruction to all children; and we must see that this is done in such a way that education rather than mere indoctrination shall result. So I think we must come out in the open and stand together for some science and nature lessons in every grade of all our elementary schools, and for some scientific instruction and training in every year of the high school.

However, it will not suffice to adopt resolutions and then turn back to our individual tasks and enterprises. If we are really to accomplish anything we must show how the thing can be done, and organize to get it done. We have been directing our efforts toward getting better instruction in the high schools, and toward developing research men in the universities, but we have overlooked the fundamental necessity of raising the general level of scientific interest and intelligence, which can be done only through science in the elementary grades. Of every one hundred children who enter our public schools approximately fifty remain to enter the eighth grade, thirty-five enter the high schools, only twenty get into the second year, only ten stick through the four years and graduate, and only five enter college.

Digitized by Google

It is of prime importance to educate our leaders; but it is of no less importance to educate the masses so that they shall know how to pick the right leaders and shall have the will to follow them. So, while we are deeply concerning our selves in giving enough and the right kind of scientific training to the thirty-five per cent who reach high school and from among whom the bulk of the leaders of the next generation will come, we must concern ourselves just as deeply with the twenty-five per cent who drop out of school before reaching the sixth grade, and the additional sixty per cent who drop out before they reach the ninth grade. These are largely those who will not be leaders, but who must be trained to recognize leadership of the right sort and follow it intelligently.

The problem of getting all the elementary pupils to study nature and science, and having them taught in such a way that their interests in scientific things may become enthusiastic and permanent is really the big problem. It will not suffice merely to give publicity to the fact that the problem exists, and is fundamental to national safety and progress.

The courses of science study must be worked out for the different grades, and written into the curriculums of all our school systems. This is a large undertaking; and it will require the cooperation of the best trained and broadest-visioned men and women now engaged in science teaching. Superintendents of schools and boards of education must be awakened to the importance of finding the solution, and must be enlisted in the enterprise. Elementary teachers who are capable of doing the teaching must be found and trained for the work. Men and women must be found who can supervise and train the teachers in service, and help them to work out lesson plans, to make teaching experiments, to test results, and to find the information that will help them in this work. These supervising experts must be able to give model lessons, and also to pick out teachers who should be encouraged to fit themselves for becoming supervisors of science. Without such expert supervision, science in the elementary grades can never be very effective. High school teachers of science must be stimulated not only to interest promising students to go on and train themselves for scientific and technical work in fields outside the schools and colleges. They must also be on the alert to pick out interested pupils who show promise of teaching ability, and induce them to prepare themselves, in normal schools and colleges of education, to become

Digitized by Google

teachers of science in elementary and high schools, and to work up perhaps into the ranks of the supervisors and college professors. Teachers of science in the normal schools, and especially those in the colleges, must get a new slant on the problem of training students for science teaching in both the elementary and the high schools.

For if these prospective teachers are to become able to choose the kinds of scientific problems and projects that are intimately connected with the children's work and interests and knowledge both within and without the school, they must know how to organize such problems and projects for teaching purposes and how to use them successfully in the inductive approach to the important principles that are to be expounded by means of them. To do such work, these prospective teachers must be trained in a very different way from that in which most of them are now being trained.

Our analysis has now brought us down to bed rock. The whole problem of reform and evolution in science education leads back directly and inevitably to the problem of attracting young men and women of ability and enthusiasm into the work of science teaching, and training them in science and in pedagogy with methods that will habituate them to approach all their teaching problems inductively, and to study their pupils and their pupils' interests and needs, no less than they study the subjects which they are to teach.

Most college and university teachers of science do not see this teacher training problem in all its bearings. Few of them realize how far reaching their influence in promoting the spread of scientific knowledge, and appreciation for the achievements of science, would be if only they would interest themselves more in promoting, enlarging, and improving the teacher-training function within their departments. Many of them quite rightly are chiefly interested in training students for research and college teaching; and apparently they act on the belief that if one knows his subject well, and is trained for research in it, he will therefore become at once a good teacher of it. We know that this is not generally true. It is my belief that college and university teachers would attract more and better material to their research courses if they would give freshman or sophomore courses in their subjects that were designed especially to show up the achievements and the methods of science, in an interesting, even spectacular way, using many experiments, and approaching every principle

Digitized by Google

inductively, so as both to make the principle stand out very clearly and to show its applications in the solution of problems of large public interest. A parallel laboratory course should be given, which might well be optional with the student, but carry its own credit. This course should not be given for technical training in preparation for the engineering or research laboratory, but should be designed to show the method and practical utility of the science. Hence the course should consist of practical problems requiring experimental solutions, and using as far as practicable the real apparatus and appliances employed in the industries concerned.

Such a course would be popular; but that should be no discredit to the professor who gives it; for it would stimulate thought and furnish a motive for intensive study, through the human interests that it would arouse. It would serve to give the students the inductive attitude and the habit of analyzing a problem before attacking it, which is essential both to the research scientist and the teacher of young people.

Finally it would serve to attract into the department larger numbers of students, among whom would be many who would become so interested in the science that they would elect the more advanced courses which the professor so delights to give, but which he often regrets are taken by so few promising students.

This course would also serve to differentiate prospective material for high school and elementary teachers and supervisors from prospective researchers; and the former should be picked out and directed into advanced courses that would give them a broad view of the science rather than merely an intensive knowledge of limited portions of it. These prospective teachers should also be brought under the influence of a type of professor that should be represented in every large university department, namely, one whose chief interest is in the teaching side of the subject, a master not only of the subject itself but also of its pedagogy in the schools, a skilled teacher of the subject, and also an inspiring teacher of teachers. He should not forego research, but his research should be in the field of the applied psychology and sociology of his science.

College teachers are wont to complain that the students who come to them have not been taught to think. Of many of these students, this is alas too tragically true. Here are a few choice excerpts, collected by one of my friends who is a professor of zoology, from freshman examination papers.

Digitized by Google

Earthworms keep the earth holely.

It is also wonderful to know how our offspring might be so that we should not marry the wrong person if we want normal offsprings.

Symmetry is the side of earthworm toward the earth.

There are two kinds of symmetry, the one that the animal can be divided by one plane as the hydra is called diabolical. Those divided by more are called triabolical.

Two classes of nematodes are dogs and other animals such as the horse and cattle. The life history of the dog begins with the formation of the parasites. The parasites being formed and with the digestive tract completed the animal is developed.

The nematoda's one characteristic is that it can stand a strong solution of a substance and cannot be effected or gotten rid of.

The structure of animals have been traced through all the different stages—from the first and through this study and infinite research work men have come to the conclusion that God did not develop as he is at the present time but that he went through a series of changes until he reached the present stage or structure. For instance we have an intestinal system something like frogs, fish, worms, etc. We have a head like frogs, we resemble dogs and cats in that they are four legged animals only they happen to walk on structures we call hands.

These choice bits of literature, the like of which can be collected in any freshman examination in any college, prove that these pupils at least cannot think and also that they have no sense of humor. Their high school teachers stand condemned, for at least if they could not teach them to think, they might have taught them not to commit themselves to speech or writing unless they could say something that would make either good sense or really intelligent nonsense. But what about the college teachers who are responsible for the training received by these high school teachers? Do they not stand convicted of deserving a greater measure of condemnation? When their educational grand-children come home to roost have they any right to disown them?

Nothing, at least in school, tends to make thinkers out of children so much as habitual incisive analytical thinking on the part of their teachers. A teacher who carefully analyzes a problem or project before he presents it to his pupils for solution, will almost inevitably plan his questions and explanatory comments in such a way as to make the pupils analyze it, and summon their stocks of relevant knowledge to their assistance, before they attack it. Now, how are the young and inexperienced high school teachers going to be able to do this thinking and analyzing and have this consequent influence on their pupils unless they themselves have been trained in doing it? And who should be better able so to train them than their college teachers of science?

Again, you cannot get high school pupils to attack problems from the inductive stand point, or to examine the grounds for

Digitized by Google

belief in general principles before accepting them, unless their science teachers use the inductive approach in their instruction, with a definite aim toward teaching them this very thing. But how can we expect young and inexperienced high school teachers —and the great majority of them are young and inexperienced, as probably you are aware—how can we expect these high school teachers to teach inductively when nearly all of their college teachers, and nearly all their text books have taught them by methods that are almost exclusively deductive?

It is very difficult for the college teacher of science to get away in his teaching from the habit of the deductive approach. When he is working on a research problem, where he is in unexplored territory, he thinks inductively, as well as deductively, but when he is doing his ordinary routine thinking or teaching, within the familiar and well organized territory of his science, he reasons quickly by deduction, directly from well established principles to conclusions. In an efficient and well trained thinker this inevitably becomes the prevailing habit. These principles he has previously arrived at or tested inductively; and they are part of his mental tools and furniture. Not so with the student. The student can get real command of a general principle only when he has arrived at it inductively through a considerable number of concrete cases, out of which he has analyzed the general principle through his own mental processes. He must have perceived in the various concrete cases the common features which the general principle describes; else he can have no real command of the principle. Until he has arrived at it inductively, it remains an item of belief, perhaps; but it cannot be an item of knowledge. So it is of fundamental importance that his teacher shall so direct him that he must do this inductive thinking himself. The crucial test of his success is ability, first to state the principle in his own words, and then to prove his knowledge of it by citing the concrete cases from which he has abstracted it, showing in them the common conditions and consequences which have served to convince him that his statement of the general principle is true.

Now, most high school teachers do not do this unless they have served a long apprenticeship, and have learned how to do it by long experience; because their high school and college teachers have not trained them to think in this way themselves.

In my judgment, one of the most important aims of our program for the reorganization of science must be to change this

Digitized by Google

condition; and I do not believe we can do much in changing it unless we can convince the college teachers of science that the reform in methods must start with them in their training of their students—especially prospective teachers. We must get them in some way to realize how important it is that high school and elementary science should be taught right, and then we must get them to feel and understand that this whole process is in their control, because they are forming the mental habits of the persons who are to do the teaching. Then we must in some way induce them to give more earnest attention to the use of inductive methods, so as to foster in prospective teachers the inductive rather than the cock-sure habit of mind.

In some way or other also, we must get these prospective teachers trained so they will understand the vocational aspects of their sciences, and may therefore be able to give their pupils the vocational information which is so essential to their success in scientific occupations.

Now we have pushed our problem of reorganization back to the college professor of science; but even were he to do all that we might suggest, we may not stop with him. You may perhaps remember the old English recipe for cooking a hare. It begins, "First catch your hare." With the best intentions and a perfectly working teacher-training organization the college or normal school professor can do nothing toward producing more and better-trained teachers of science, unless he can get into his classes young men and women who want to become teachers, and who have the native ability to qualify.

Even when our high school teachers succeed in sending up graduates who are deeply interested in science, and anxious to prepare themselves for work in scientific pursuits, very few of these choose science teaching as a career. The reason for this is quite plain. They go into the scientific and technical occupations of the industrial world.

The salaries of teachers and professors are so low that the high schools and colleges cannot compete successfully with the industries in bidding for talented and trained young people. With few exceptions, the schools are getting the culls, and there are not even enough of these to fill the positions.

The teachers are employed by boards of education, who by now, understand this problem pretty well, and are willing to pay better salaries to get competent teachers and keep them; but the pay comes out of the public purse.

Digitized by Google

So we have gone around the vicious circle and got back again to the tax sheet and the individual pocketbook, where every question of a public nature begins and ends.

What can be done? The public purse is always lean, mainly I believe because our methods of taxation are so imperfect and inequitable that we do not succeed in getting on the duplicate all the taxable property that should be there, and at its fair valuation. Hence, the rate is always too high; and the tendency of tax-payers is always toward keeping the rate as low as possible instead of toward devising means of getting a fuller and juster valuation of all property that should be taxed.

So far as I can see, the only hope of breaking into this closed circle, is through organized publicity and agitation. The public must be educated so that they will understand the economic value of competent teaching. We need to give more attention to publicity for the science courses within the schools, so that more pupils shall want to study science and study it more enthusiastically and industriously because they shall have been made to realize its value. We need also to make this value known to the people, so they will be willing to invest more money in competent teaching.

Individual science teachers can do much, if they will, in carrying on such publicity work in their schools and local communities; but if we are to succeed in carrying out the large program that has been outlined, there must be formed a compact and powerful country-wide organization of scientific workers and teachers, to carry on the propaganda through a period of years.

Fortunately, we already have the decentralized units from which a central committee can be drawn that would function in binding all these groups together, and securing unified action.

This central committee might be made up from representatives of the National Council of Defence, the Bureau of Standards, the Bureau of Education, the Departments of Agriculture and of Commerce, the Smithsonian Institution, the American Association for the Advancement of Science, and its affiliated societies, The National Education Association, and other influential bodies such as this one, which are interested in the promotion of science and education.

Through plans worked out by the central committee, united action might be secured from these influential organizations for carrying the campaign of education into every section, state, and community.

Digitized by Google

The committee might secure articles for publication in the magazines and newspapers showing the need of science, and the fundamental importance to industry of science teaching in the production of trained scientific and technical workers. It might supply speakers to address chambers of commerce, industrial organizations, and women's club federations, and impress upon them that teaching is one of the basic factors of production, that it is not only worth while but necessary, that the industries should cheerfully tax themselves to promote scientific teaching, and that they should count it as one of the essential cost factors in production, or if not that, an investment that would yield large returns.

This committee, through the societies affiliated in it might exert a tremendous influence, through local pressure, on the boards of education and the school systems in the states and communities where their members reside. The united influence of all these societies might be brought to bear on congress in behalf of larger and more cordial support of those departments and bureaus of the national government which are doing such splendid scientific work and which would do so much more and so much better work if they were more generously supplied with funds.

Finally, these organizations might be brought to put all their weight and all their power behind the movement for a national university at Washington which should be the clearing house and center of inspiration of all movements for the spread of knowledge and the promotion of efficiency in every national enterprise for the common good.

SCHOOL CHILDREN DEMAND METRIC SYSTEM.

The World Trade Club is daily receiving evidence as to the growing strength of public opinion throughout Britannia in favor of metric standardization. Just the other day word came from one of their co-workers in England of an interesting episode that took place during one of his lecture tours.

At Kingsbridge he spoke before a gathering of enthusiastic schoolboys from the local grammar school, telling them of what adoption of the metric units of measurement would mean to the school children of the world—how easy metrics are to learn, how simple to apply—in short, that it would lessen the necessary time spent on arithmetic by three years.

At the close of his talk, the boys unanimously adopted a resolution urging other schoolboys to go on strike with them against the Bri ish weights and measures, and demanding that only metrics be taught in the schools. These English youngsters realized the increase in efficiency, and the immense saving of time and labor obtainable through meter-liter-gram.

Digitized by Google

THE USE OF ENGLISH IN SCIENCE COURSES.

By E. H. Johnson,
Kenyon College, Gambier, Ohio.

Probably every science teacher who has given any thought at all to the matter of expression has been impressed with the failure of his students to use good English when writing a report on a laboratory experiment or in an examination on a scientific subject. In the latter case, some allowance may be made for haste—the desire to cover the required amount of ground in a given time—but one cannot help wondering if similar crudities would appear in an English paper no matter how great might be the need for speed, not simply because the student expected in this case to be graded on his form of expression, and would therefore take greater pains than in a science test, but because in his literary training he had been taught to emulate the amenities of literature rather than portray faithfully the things and experiences actually found in life.

The science teacher who is desirous of giving his pupils full credit for subject matter assimilated is continually at a loss to know to what extent their written or oral expressions are indicative of their mental grasp of the points in question. Often he feels that So-and-So's recitation or examination is not a mark of his knowledge, and yet he may have no reason to question the seriousness of the student's effort. I do not refer to the purely careless type whose work is illustrated by the quotation given by James: "The birds filled the tree-tops with their morning song, making the air moist, cool and pleasant," but rather to another group of whom a recent college graduate was typical. While he was a senior, his instructor in one of the laboratory courses, having become wearied by the student's failure to use even a reasonably appropriate form of expression, and his difficulty in making a good, clear-cut report on a simple experiment, remarked that it might be a good idea to turn over some of this written work to the English Department—that possibly the instructor there might know how to remedy the difficulty. The suggestion was made partly as a jest. The student, however, taking the remark seriously, replied: "No, no, please do not do that, for I have a good grade in English."

Such a condition and the consequent conversation, probably indicate one of three things, either the English teacher was giving grades which were not deserved (which is highly improbable),

Digitized by Google

or the pupil was really careless, or, his practice work in exposition had been very limited and had dealt with subjects so remote from the phenomena of actual existence, that he was attempting a new task when he tried to form a virile expression relative to things as they are.

Not long ago, a science teacher who had been impressed with this same difficulty, mentioned the matter to one of his colleagues, a teacher of the English language. With no spirit of adverse criticism, he asked the latter if it were not possible to give more time in English work to reading and composition descriptive of actual conditions more or less of a scientific nature. He asked if time was ever spent in reading from the writings of men such as Faraday and Tyndall, men whose fame was in part due to their ability to express simple or great thoughts in the simplest of language, with a diction meaningful to an extent seldom approached in ordinary literature. He asked this English teacher if he knew about a certain text-book of selections in the English language chosen from scientific writings, and to all of these inquiries the answer was in the negative, with an added statement that these fields contained no material of interest for him—and as for the text-book—he didn't know it and he did not care to. In general, he probably spoke the truth. Perhaps he would have answered a fellow language teacher differently, for a mere matter-of-fact scientist could not possibly possess vision byond that of the gross things immediately around him. Hence, in criticising the general use of the vehicle for the exchange of ideas, the latter was distinctly out of his proper domain.

Be that as it may, the difficulty does exist. College graduates are unable to write or speak correctly in their own native language, and their trouble seems to be greatest where directness and simplicity not only lend effectiveness, but are almost essential to correctness.

The sentence quoted from James was undoubtedly the result of a hasty attempt to produce a beautiful expression, the interest of the writer being in the artistic appearance of the sentence rather than in the significance of the thought itself. In contrast to this kind of failure is that of the student in physics, who, after a serious attempt to produce a definition, wrote: "Inertia is the force that keeps a body moving after it has stopped." It may very properly be argued that this statement also shows ignorance, but a short conversation showed that the student knew the meaning of "inertia." He had a very fair idea of what

Digitized by Google

he wanted to say, and he appreciated the absurdity of his own statement when it was pointed out to him, but even then he was unable to make much improvement in it, save to indicate by a separate statement that the word "stopped" should refer to the force and not to the motion of the body.

Again, take the following, given as a definition of a component of a force: "When two or more forces act to produce a resultant force, a component of that force is one of the two or more forces producing the resultant." We must admit that he "got there," and that his expression is not grammatically wrong, but unless the question as well as the answer were known, it would be difficult to know just what point on the circle is the desired destination.

Oral questioning immediately after the written exercise showed that this pupil also had a fairly correct idea of the meaning of the term he was trying to explain. In his English class he had a high standing. What was the trouble? This last question was also put to him, and he answered it, undoubtedly with more success than in the former case. "In our English work we don't study this sort of thing, where you've got to be so careful about what you say in order not to be all wrong. In an English paper we can say a thing in a good many different ways, and still perhaps be all right." In a science paper, however, too wide a deviation from a careful form of wording may make the definition all wrong. (This, of course, does not mean that the text should be memorized.) In other words, his training may have fitted him fairly well for the production of general expressions about almost anything, but the making of a definite statement about a detail was beyond his power.

It is not a point in the present discussion that language students should be drilled in the forming of definitions, nor in the use of technical language, but there can be little question that a masterly expression, like a creation of Rodin, has beauty because of its meaning, though it may be utterly lacking in polish.

Where can one find examples more worthy of emulation than in the writings of such men as the two physicists named above? Their form of expression was eminently successful because great ideas were conveyed in simple language that everybody could understand, and yet in language so adequate as to put to shame many of the lengthy endeavors of the literati of the ages.

Schools of oratory, law schools, theological seminaries, and more generally, all of the departments in that greater university

Digitized by Google

of world activities, know the need of men whose training has given them not simply the ability to think, but the power of persuasive expression. The world has long since learned that a master of formal logic cannot argue successfully on the great questions relating to things as they are with the man who, knowing the facts and possessing a fair vocabulary, has learned how to express his thoughts simply and definitely. This "great plainness of speech," and "sound speech that cannot be condemned" —so well appreciated by the Apostle to the Gentiles—perhaps more than any other single characteristic has given us the immortal speeches and writings of the centuries.

It may be suggested that there is a close connection between the mental power of an individual and his ability to express his thoughts definitely. This is probably true, but at the same time complete expression does not necessarily imply the power of tongue or pen to produce polished phrasing, poetic diction, or arguments impressive because of their length. A complete idea is an entity. In the terms of logic and metaphysics, it may be regarded as an actual whole and hence it exists only when all of its component parts exist, and not the least among these is the mental framing of more or less complete phrases descriptive of the fact in mind. Accordingly, a normal person should have no difficulty in stating his thought to others, if he really has the thought. And yet there are numerous examples every day of utter failure to express the ideas undoubtedly in mind. The difficulty seems to be due to insufficient training in exact expression.

Ideas on a subject, no matter how limited they may be, from the very fact of their existence, may be expressed completely if the individual is sufficiently skilled in the coordinated use of brain and tongue or pen to manipulate the tools required for the job in hand. Expertness with any kind of tool is acquired through use. Definite expression is an art in which every member of the social family should be expert.

Rather than designate the present era as a scientific or a materialistic age, I prefer to regard it as a period of transition from an inadequate order to one of which the criteria are all to be based on the continual analyses of thoughts and statements to see if they are as nearly as all possible present skill can make them in accordance with actual facts. With such standards, with the increasing interest in the world about us, in our fellows and in a common aim—whatever each of us may conceive that to be

Digitized by Google

—it cannot be denied that even as clear seeing and clear thinking are essential to this progress, these latter factors are in turn dependent on clear, definite expression if they are to become general accomplishments. To the writer, even the trifling difficulties discussed in this paper mark a vulnerable point in our educational system. It may not be "all of life to live," but there is an unquestionable relationship between life and the living of it, and the life of an age is that of its thinkers. These of necessity are largely its speakers and writers, that is, all who can express themselves adequately. This does not mean technically, nor with studied phrasing, but with that ability which may be acquired only with practice in exposition in which the subject matter, in part at least, deals with things in the world about us—things as they actually are.

Having passed through great ages of generalization, such as that in which Darwin lived, we are again living in a period of specialization, a period during which information is being gathered, definite laws are being discovered by scientists, definite problems are being investigated and solved, to furnish material, perhaps, for some greater generalization at a later time. Hence it is that, as never before, the ability to express one's thoughts on many subjects is absolutely necessary. This does not mean that he must be phenomenally versatile, it does not mean that he should dip into all lines of thought, but it does mean that he must be able to express clearly and concisely whatever thoughts he may be capable of having.

Whatever the value of a study of the past, we must not let it overshadow our appreciation of present developments in all lines of human activity. The efficiency necessary for successful existence and survival in the great competitive struggles of today requires not only definite action, but too, that definite expression of which I have been speaking. Unfortunately, this form of expression does not seem to be acquired in the average home while the child is young. Likewise it seems unattainable in the elementary schools, possibly because there the environment is so radically different from that to which the child has become accustomed at home, and also because of the great variety of tasks that are attempted. Hence it is that a greater definiteness of expression must be insisted upon in high schools and colleges, that the requisite habits in this respect may be formed before the student has passed beyond the habit-acquiring age. Inasmuch as science teachers, among others, have felt the need of

Digitized by Google

such improvement, let them commence the good work, if need be. Let them defend the argument that for the ordinary individual, the development of imaginative ability of a high productive type must be preceded by exact training in exposition involving a definite amount and a definite kind of information.

In this paper I have referred only to those instances where a really serious attempt is made at clear expression. The difficulties discussed seem to be most apparent in oral and written statements on scientific subjects, where, for complete truth's sake, concise expression is not only desirable, but absolutely essential. And I wish to emphasize the fact that what has been said is not meant as a criticism of English teachers or their work, for the work of every teacher is too exacting to permit of adverse criticism by any other. It is offered as an indicator of a real difficulty that has impressed one who is himself a teacher of science. For it is undoubtedly true that not until a correct use of the English language is demanded of every student, whether in the English classroom or in the laboratory, or in any other environment—not until then will he acquire the familiarity with his native tongue which will make him use a correct form of expression automatically and without a painful attempt. Then only can he give his thoughts so completely to the subject matter, that the resulting statement, no matter with how little effort it may be formed, may present at once the essential qualities of accuracy and the degree of elegance reasonably to be expected in a good form of speech.

GASOLINE FROM NATURAL GAS.

The recovery of gasoline from natural gas has now become a large industry, which contributes materially to the supply of motor fuels. Experiments in the conversion of natural gas to gasoline were made as early as 1903, but experiment did not give way to commercial production until about 1910. The growth of the industry since that year has been remarkable. In 1911 there were in operation 176 plants, which produced about 7,400,000 gallons of raw gasoline from natural gas. In 1917, only six years later, there were 886 plants, which produced nearly 218,000,000 gallons. Prior to 1916 most of the gasoline recovered from natural gas was derived from casing-head gas obtained from oil wells, by methods involving compression and condensation, but from year to year an increasingly large proportion of the annual output of natural-gas gasoline has been recovered by the absorption process, which has now been applied not only to "wet" gas from oil wells but also to so-called "dry" gas, which occurs independent of oil and constitutes the main supply of natural gas. Dry gas can not be profitably converted into gasoline by compression.

Digitized by Google

THE PROJECT AS A TEACHING METHOD.

By R. W. Sharpe,
DeWitt Clinton High School, New York City.

The criticism that the subject matter taught in schools is quite largely isolated from the experiences of pupils outside the schools has led to the formulation of the project method of teaching.

The method of the project had been variously interpreted with various results—mainly unsatisfactory. Most failures result from lack of recognition (1) that projects must precede principles, (2) that principles are better understood when developed as the learner needs them, (3) that projects must be organized, so far as possible, in their natural setting.

Faulty organization of material and projects has no doubt caused most of the poor results in science and other teaching. Widespread study of the causes of faulty organization has resulted in a formulation of the term project that, if consistently carried out, will doubtless eliminate much of the unsatisfactory results toward which honest and well considered criticism is now directed.

The term project has probably been most satisfactorily defined as "A problematic act carried to completion in its natural setting." (Stevenson.) This evidently means that there must be (1) no passive reception of information by the pupils, (2) reasoning rather than memorization, (3) priority of the problem over the learning of principles, (4) a setting for the problem in the schools as near as possible to that found in life outside the schools, (5) a plan of action looking into the future which, when carried out, results in a thing accomplished.

A splendid characterization of the term project has been given by Dr. C. R. Mann[1] as "(1) A desire to understand the meaning of some fact, phenomenon, or experience. This leads to questions and problems. (2) A conviction that it is worth while and possible to obtain an understanding of the thing in question. This causes one to work with an impelling interest. (3) The gathering from books, experiences and experiments, of the needed information to answer the question in hand."

This means that the student works in much the following order: (1) A state of perplexity or of curiosity; (2) work is begun with enthusiasm because this perplexity or curiosity is the

[1] Woodhull, *General Science Quarterly*, Vol. 2, p. 249, Nov., 1917.

Digitized by Google

result of a real desire for a solution; (3) once the difficulty is clearly defined the pupil's enthusiasm carries him to a solution which is almost automatic, but which in reality is (a) a process of supposition, guess, theory or hypothesis, pending further evidence, (b) reasoning out the evidence as discovered, (c) deliberate weeding out of the false so as to arrive at a conclusion, (d) application of the conclusion to other similar situations.

Quite likely most teaching is done by topics rather than by projects.[2] "Projects are superior to topics, in that the project originates in some question, and not in a logical arrangement of matter as found in most texts. While teaching from topics in textbooks, the teacher wrongly attempts to induce pupils to accept topics as their own projects. Topics mean a formal didactic treatment in which the teacher does all the thinking and the pupil absorbs and memorizes. Projects in their life setting lend themselves to a selection of facts according to their value or significance to the pupil. Topics furnish no such basis for selection."

Again, many teachers who recognize the value of the project method, fail to carry the method of the project to a satisfactory conclusion. This results from the attempt to cover too much ground, and the teacher attempts to hurry the pupils, forgetting that what may be very simple and obvious for the teacher may be very obscure for the pupil. The teacher, therefore, interrupts with his own thinking, and prescribes the procedure to be followed by the pupils to such an extent as to kill the student's initiative. Too much text book work brings about the same result, while a good reference book in the hands of the pupil, to be used as he feels the need for it, is quite another matter.

With the foregoing status of the term project in mind, as used in science teaching, the writer presents below some observations made of the methods used by a few writers of texts and so-called syllabi in science, with a view to discovering to what extent these writers are succeeding in teaching or organizing by the project method, as defined by our best authorities.

Let us take the subject of transportation. One text contains the following organization of subject matter.

PROJECT XVII. TRANSPORTATION.

1. Importance of transportation—Animal power compared with steam and electric power.
2. Water as a medium of transportation—Why substances float or sink.

[2] *General Science Quarterly*, Vol. 2, p. 2, Nov., 1917.

Digitized by Google

3. Archimedes principle—Specific gravity—Submarines and the floating of iron ships.
4. Steam engines—The first steam engine—The principle of the steam engine. Locomotives and steamships.
5. Steam and gas engines compared. How a gas engine works—The automobile.
6. Electric power—The parts and working of an electric motor—Electric cars and locomotives.
7. The dynamo compared with an electric motor—The principle of the dynamo.
8. Power stations.
9. Kinds of water wheels.
10. Water power and the protection of forests.

Here transportation is evidently not a project, although so named, but is really a chapter heading. An introduction is given as preparatory material properly enough, followed by some "problems" or experiments, as follows: (1) Why do some objects float in water? (2) what is the specific gravity of iron? (3) What is the principle of the steam engine? (4) What is the principle of the gas engine? (5) How does a steam engine work? (6) Study of an electric motor. (7) Study of a dynamo. (8) Visit to an electric light station.

This is followed by a number of topics amplifying the principles which motivate the giving of the didactic problems and exercises given above. This in turn is followed by a number of "individual projects."

This violates the characterization of a project in that, (1) there are few real problems at issue that are similar to those arising in real life. There is little or no natural setting. The pupils are led arbitrarily and didactically to consider (a) why objects float, (b) the specific gravity of iron, (c) the principle of the gas engine, (d) the principle of the electric motor and dynamo. There is no staging of the real problems. Certainly pupils would not naturally follow this order in attempting to solve the problems of transportation, let alone calling the general chapter heading a project. Here principles come first, followed by applications—a discarded method.

The use of a natural method of organization would much more likely result in staging the material somewhat as follows:

1. What makes boats float and submarines sink?
2. How may we transport a comparatively heavy load with a small force?
3. How may steam be used to pull heavy loads?
4. How may water wheels be used as a source of power?
5. How does electricity run a street car?
6. What makes things go?

These are likely questions that arise in the minds of pupils. There is no thought of the scientific principles involved or of

Digitized by Google

the atmosphere of the schoolroom. Of course, pupils might bring up these questions in somewhat different wording or order, to be immediately seized upon by the teacher acting as stage manager or director. Principles are ultimately arrived at, if these projects are solved to a satisfactory conclusion. Generalizations and applications naturally follow.

Another recent text presents the same matter as follows:

CHAPTER VI. TRANSPORTATION ON LAND.

1. Vehicles—Primitive vehicles—Transportation and topography.
2. Roads and vehicles—Kinds of roads—Roads and motive force.
3. Railroads—Location of grades.
4. Curves, inertia and effect—Effect of change of direction.
5. Bridges—Principle of the girder—Truss, tubular and suspension bridges.
6. Steam and the locomotive—Operation of the steam engine—Condensers.
7. Production and control of steam—Boiling temperature and high pressure—Amount of heat required—Evaporation and condensation, etc.
8. Electricity as a motive power—Motors—Generators and transformers.
9. Gasoline as a motive power—Gas engines—Dependence upon other mechanisms.

The above topics are explained and made clear by means of ample exercises which are good in themselves, but again there is no attempt to organize the material around the questions naturally arising in the minds of the pupils. That the topics are likely intended to serve as suggested projects, is evidenced by the author's statement in the preface, as follows: "The general method of the book in dealing with the topics, or projects, selected for study is broadly inductive or heuristic, etc.," although the term project is not mentioned elsewhere in the book, so far as the writer can discover.

Another recent syllabus attacks a portion of the topic transportation, confined mainly to the source of the necessary energy, under the chapter heading "Relation of air to everyday activities," as follows:

RELATION OF AIR TO EVERYDAY ACTIVITIES.

A. Oxidation.
  What makes an automobile go?
  Oxidation of gasoline.
  Examine diagram of an automobile engine.
    Find parts corresponding to a simple cylinder—
      (a) Piston and cylinder.
      (b) Wires carrying electric current.
      (c) Place where spark is produced.
      (d) Tube carrying gasoline and air.
      (e) Carburetor.
  How is the power developed by the explosion in the cylinder applied?
    Toy crank shaft diagrams of gears.
  Action of a 4-cycle engine.

Digitized by Google

Diagram showing,
(1) Suction stroke.
(2) Compression stroke.
(3) Power stroke.
(4) Exhaust stroke.
Why do autos have fly wheels?
Advantage of an engine having many cylinders.
How the spark is produced in an auto.
Need for a timing apparatus.
Need for arrangements for cooling engine—air and water cooled.
Need for an oiling system.

B. Burning or oxidation as a source of power.
Other substances used as fuel.
What happens in burning.
Burning a match—rusting of iron—other causes of slow oxidation.
Spontaneous combustion—explosions.
Why coal is burned.
Need for energy in human body—how supplied—need for a blood system.
Do plants breathe as animals?

C. Prevention of destructive oxidation.

D. Importance to us of the gases other than oxygen that compose the air.

The writer of this syllabus alludes to the term project only in the following sentence: "Pupils should be encouraged to work out certain *projects* or *topics* suggested by class work, each pupil to demonstrate the project to the class at a later period." Seemingly there is no attempt to distinguish between topics and projects. The term problem is frequently used, but there is little to suggest, and it is not likely that this term is used to signify a project.

The best definition of a project would exclude such a heterogeneous collection of topics as above given under the heading "Oxidation," but would be best met by organizing the material about a project in its natural setting, somewhat as follows:

PROJECT—WHAT MAKES ANYTHING GO?

Introduction or Approach.
What problems arise for solution?
Evidently something is needed, associated with heat-energy.
What else needed? Evidently a fuel, and some means of control as a stove, engine, etc.

Reasoning.
Need for a kindling temperature—example of the match.
Given fuel and a kindling temperature, is air necessary?
What portion of the air is used? Burn phosphorus.
This portion called oxygen—rest mainly nitrogen.
Oxygen supports burning or combustion.
Combustion of wood or iron wire in oxygen—example of rapid oxidation.
Rapid oxidation of gasoline in a "coffee pot cylinder."
Fuel must be in a condition to burn very rapidly, and must be confined or controlled.

Conclusion.
Demonstration by pupils, showing how rapid oxidation of a controlled fuel "makes things go." That given the proper fuel, the proper kindling temperature and air (oxygen), there is still needed a means of using the resulting energy and a means of getting rid of the wastes.

Digitized by Google

This naturally leads to a discussion of the adaptability of various fuels for different purposes, and what happens when they are burned. Problems sure to be suggested and worked out in class or by individual pupils as independent problems are:

What happens when a candle burns? When we burn a match? How to make a match? Cause of smoke? Stoves, gas ranges, lamps, etc.—rusting of iron—this called slow oxidation.

Spontaneous combustion and explosions, etc., and how prevent destructive oxidation.

Sooner or later will arise the question "What makes living things go?" This leads to a study of foods as fuel, means of getting oxygen into living bodies, and how get rid of the wastes.

The pupil is thus led to solve in some such manner as above the general import of the project "What makes things go?" or the source of power or energy, before he concerns himself with the machinery of autos, etc., necessary to handle this energy. Some pupils, indeed, may wish to work out the mechanism of an auto, but in the main he should be discouraged at this particular point as being much too difficult for the average pupil. Here it is the business of the teacher as director to see that pupils do not bite off more than they can chew, let alone digest.

The method just outlined permits of a natural setting, forces the attention upon the problems at issue, and facts and principles are learned almost unconsciously. The natural setting provides a strong motive. Finding out "What makes things go?" is far more interesting than any study of oxidation introduced as such, or "The Composition of the Air" or "The Relation of Air to Everyday Activities," or "What makes an automobile go?" if that means much attention to mechanical details.

While all projects may not be equally interesting to all pupils, yet interest in projects selected by pupils is likely to be very intense. All of this means that in place of a so-called syllabus, so commonly used as the basis of the course in science, projects form a much better basis. It is only necessary to decide what facts and principles should ultimately be mastered by the pupils, and then select groups of projects from which the pupils may make selections. These selected projects will be such that all the facts, processes and principles needed will be covered which are commonly given in the logical or systematic presentation of the subject. The project is used as the *approach* in all cases, after which it is comparatively easy to systematically summarize the entire field, if desirable.

Digitized by Google

SUMMARY.

1. Projects must precede principles.
2. Principles are better understood when unconsciously worked out as the pupils need them.
3. Projects should be offered in their natural setting, so that the situations undertaken in school are not essentially different from what they would be if undertaken in the environment outside the school.
4. The applications of the principles learned in solving such projects readily suggest themselves in solving other problematic situations.
5. Topics as given in ordinary syllabi lend themselves to no such treatment.
6. Projects encourage the pupils to do their own thinking, while the teacher acts as guide and counsellor, and provides the stage setting.
7. Even a mediocre text in the hands of the pupil, *to use when needed*, gives confidence to the weaker pupils, and assists them over many an obscure point.
8. Syllabi are as deadening to teachers as to pupils, and explain much of the poor teaching done in our science classes. Teachers are just as likely to be interested in projects as are the pupils.
9. Many suggestive projects should be outlined in a course of study, in place of a syllabus. These projects should be such as to include all the facts, principles and processes which are commonly covered in a logical or systematic presentation of the subject. The topic method is thus avoided—a method deadening alike to teachers and pupils.

DEPOSITS OF CHROMITE IN ALASKA.

Deposits of chromite have been known in Alaska for several years, but they became of economic interest only in 1917, when the high price of the ore made it possible to mine it commercially at one property. The chromite deposits of present interest in Alaska are at the southwest end of Kenai Peninsula. A description of the deposit now mined and a map showing its location are given in a short paper by J. B. Mertie, Jr., published as part of Bulletin 692-D.

HELPING THE TEACHER TEACH.

"If the teaching of agriculture is to have any permanent effect upon community life and practice, it must have a vital connection with the daily experiences of the pupils and must utilize the latest and best information available. The teacher must so organize the available subject matter that it will touch closely the pupil's life and experiences."

That is the opinion of the United States Department of Agriculture, expressed in the prefatory paragraphs of Department Circular 69, "How Teachers May Use Department Publications on the Control of Diseases and Insect Enemies of the Home Garden."

"In order to give the teacher some material assistance along these lines," continues the introduction, "leaflets indicating how teachers may make use of information contained in publications of the United States Department of Agriculture have been prepared and it is hoped that they may help to improve instruction in agriculture and kindred subjects in the schools and directly connect it with community interests. The leaflets are designed especially for teachers in elementary schools, but in many cases will be found suggestive and helpful to teachers in secondary schools and in urban as well as rural schools, depending upon the subject matter and the interests of the community served by the schools."

The circular indicates how the teacher may so closely connect the information given in the department publications with the every-day experiences of the pupils as to place the subject among the things of common interest to the average child. Copies may be had upon application to the Division of Publications, United States Department of Agriculture.

Digitized by Google

A HIGH SCHOOL COURSE IN TRADE CHEMISTRY.

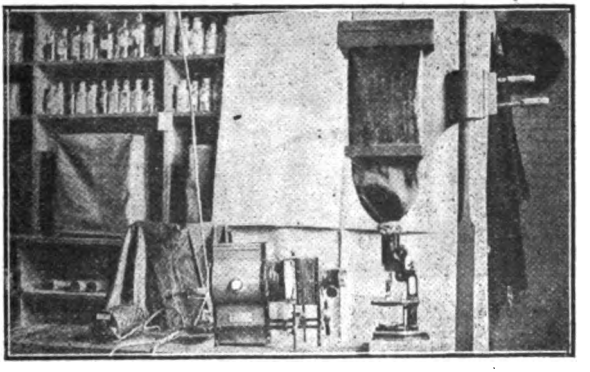
By Edwin G. Pierce,
East Technical High School, Cleveland, Ohio.

The possibility of introducing chemistry as a trade course into secondary schools is a question of interest and importance.

America's rapid approach to supremacy in chemical industries gives her the splendid opportunity to take the lead in chemical education and research.

From this point of view, it is important that consideration be given to industrial as well as theoretical and descriptive chemistry in secondary schools as a means of providing the industries with skil'ed workmen, and laying a foundation for greater developments in higher technical education.

The number of small industries installing "works" laboratories for control purposes is increasing daily, affording more opportunities for young men and women as assistants than ever before. Clerks, stenographers, secretaries, and salesmen having some knowledge of industrial chemistry are now being more and more required.



Microphotography.

It is not to be supposed that a high school course can be substituted for college training, but such a course will give those unable to go directly to college a chance to secure a start in technical work, and later to approach their higher training with more mature judgment and appreciation. It will also give the industries an opportunity to employ young people at a time of life when they are most easily trained for particular tasks, have less to *unlearn*, and have the greatest amount of energy and enthusiasm.

Digitized by Google

In addition to the educational possibilities of any trade course, such as the training in how to go about a piece of work, industrial and analytical chemistry furnish the advantage of combining mental with manual training in a manner that is unique. The machinist can see what is to be done and follow the progress of his work with the eye, touch, and tools, but the chemist, in addition to the manual operations of analysis, must constantly project himself into the realm of the invisible and unknown. Unseen atoms, molecules, and ions are his tools and materials. Being able to deal with invisible entities to produce real results of a high degree of accuracy is splendid training in working at abstract problems of any sort, and gives the student more actual faith in scientific theories.

HOMEMADE OUTFIT FOR METALLOGRAPY.

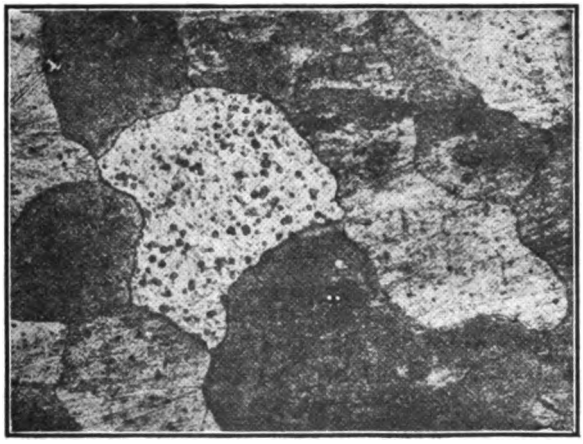
To arrange a high school course in trade chemistry which will produce training of practical value and also prove its worth as an educational factor is not an easy matter, but is entirely possible.

There are several considerations of prime importance. The instructor must have considerable actual experience as an industrial chemist. No amount of college training or summer courses can give the proper point of view nor prepare one to teach this subject understandingly. Students must have sufficient uninterrupted time in the laboratory to complete an appreciable amount of analytical work. The analyses must not drag along endlessly without results.

Digitized by Google

To the writer this last consideration is the critical point of the whole matter, and a solution of the problem was found by substituting rapid, up-to-date control methods for the antiquated exercises usually found in analytical textbooks. In a trade course, it is essential that the student learn, for example, that the "Raw Mix" in the Portland Cement industry cannot be held back from the kilns for a week while the chemist analyzes it by academic methods; it must be "jerked" within fifteen minutes but must be accurate within certain well defined limits.

These rapid methods fit admirably the necessities of a high school course. The students learn a wholesome respect for accuracy, and appreciate it all the more when a source of error



TOOL STEEL AS RECEIVED UNANNEALED, MAGNIFIED 100 TIMES

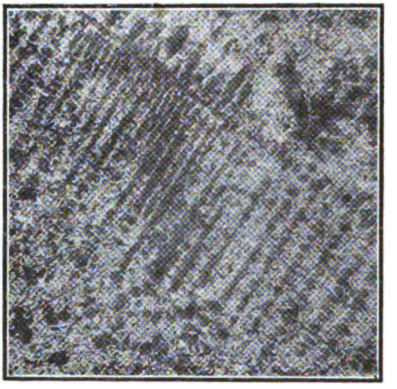
brings its result while the error is still fresh in mind. Getting results within a reasonable length of time means as much to the embryo chemist as the game on Saturday does to the football player after a week of hard scrimmage. Also, the rapid methods, when properly developed, are just as educational and involve just as important chemical considerations as the longer ones.

A great deal of work is required in preparing for such analytical work. The students must do their share of calibrating, standardizing, and other tedious jobs, but this work must be limited so that the students will not lose interest. Analyzed samples and detailed methods must be had. These are best, but not easily secured from local industries.

The majority of industrial men will not, at first, believe that high school graduates can do real chemical work, but once convinced and interested, are very willing to aid the course.

Digitized by Google

While a trade course is designed primarily for those not expecting to go directly to college, the question of its utility for college preparatory students is sure to rise, since nearly every high school student hopes to attend college sometime. The trade course in itself is a powerful stimulus toward higher education, because the student learns the value and applications of chemical theories which otherwise are only hard facts to be known at examination time and then forgotten.



DENDRITIC STRUCTURE IN LEAD ANTIMONY ALLOY, MAGNIFIED 100 TIMES.

Having taught college chemistry and served as head of the department of chemistry in a university for some time, the writer may be permitted to express an opinion, that tracing out the chemistry of industrial processes and successful effort to secure accuracy in the analytical operations controlling them create a deeper interest in the study of chemical facts and theories and constitute a better preparation for college chemistry than all the academic lore with which the student can be stuffed. Also that all education should be preparation for real life. The writer firmly believes that the real test of the educational value of college preparatory courses should be that in case the student is unable to go to college he will still find himself as well prepared for life as four years of high school can make him. If college requirements have warped our secondary education into something that is unreal and of little value in itself, then college requirements, or our control by them, should be changed.

There is, however, the difficulty that college preparatory students have less time to devote to laboratory work. This difficulty can be met by giving these students the same recitation periods, but cutting down the number of laboratory periods

Digitized by Google

and allowing them to complete a smaller number of industrial problems.

Ohio State University has been giving full credit for the course in trade chemistry at East Technical High School, Cleveland. An outline of this course with the suggested alteration to suit college preparatory students may be of interest.

The usual one year course in high school chemistry is a sophomore subject, after which the student may elect the two-year course in trade chemistry, putting in four forty-five minute periods per day, one of which is devoted to classroom work.

OUTLINE OF COURSE IN TRADE CHEMISTRY, EAST TECHNICAL HIGH SCHOOL, CLEVELAND, OHIO.

Complete trade course

	Recitation period			Laboratory periods		
Class	Description	45 Min.	Credit	Description	45 Min.	Credit
11 B	General Chemistry Qualitative Theory	1	5	Qualitative analysis 35 unknowns	3	7½
11 A	General Chemistry Chemistry calculations	1	5	Quantitative methods and simple analyses	3	7½
12 B	Industrial Chemistry	1	5	Rapid methods of industrial analysis	3	7½
12 A	Library and conference	1	5	Specialize on analytical methods of one industry	3	7½
			15			30

Suggested modification of trade course for college preparatory students

	Recitation period			Laboratory periods		
Class	Description	45 Min.	Credit	Description	45 Min.	Credit
11 B	Same as trade course	1	5	Qualitative analysis 20 unknowns	2	5
11 A	Same as trade course	1	5	Quantitative methods and simple analyses	2	5
12 B	Same as trade course	1	5	Rapid methods of industrial analysis	2	5
12 A						
			15			15

Digitized by Google

Commenting upon this arrangement, it might seem that too much time is given to general chemistry. This could be modified, but it is felt that students can not be too carefully drilled in the fundamentals of chemistry and the repetition from a more advanced point of view clears up much that was hazy in the elementary course, and brings more clearly the realization that chemical theories are not merely abstract ideas but the real tools of the chemical profession.

In the study of industrial chemistry, no attempt is made to cover the whole field, but some half dozen fundamental industries, including those of local importance which the class may visit, and in which students may find employment, are thoroughly investigated. Fuels, water and lubricants are the first topics, then the industries in the most convenient order.

Continuity of ideas and operations is sought throughout the course. For example, one of the first exercises consists in precipitating barium sulfate from portions of a carboy of sulfuric acid made up a little stronger than fifth normal. From this, an exact fifth normal alkali is prepared and from that a fifth normal solution of nitric or hydrochloric acid; these are then compared and corrected, and further checked by running an analyzed sample of calcium carbonate or iceland spar by the acid and alkali method. Then each student runs a number of limestone samples by the Newberry method for calcium oxide and magnesium oxide, until he is able to make a determination quickly and accurately.

Iron and steel come in for an extra portion of time at East Technical. The rapid methods for silicon, sulfur, phosporus manganese, and carbon accompany a study of the primary metallurgical processes, and field trips are made to blast-furnace, open-hearth, Bessemer, forge and foundry plants in the city. The elements of metallography are also presented with the aid of a home-made outfit which produces excellent microphotographs, and serves to give the students an idea of what can be done with that method of examination.

In addition to cement, iron and steel, other topics taken up in the trade course are—rubber, paints, oils, varnish, general chemicals, petroleum and salt. Various industrial companies have kindly furnished sets of analyzed materials and detailed descriptions of their routine methods of chemical analysis for these topics. These solutions are used for other analyses.

During the last semester it is planned for each student to

Digitized by Google

take up more intensive study and training in the industry he is most likely to follow, or, if he can secure half-day work in an industrial laboratory, he is allowed to substitute that for the four periods he would otherwise spend in the school laboratory. The latter arrangement has several advantages; it puts the student at the disposal of the employer when needed, instead of the entire class going out all at the same time to look for work; it also aids in securing cooperation between the school and the industries.

Records indicate that a majority of those completing the high school course in trade chemistry go eventually to college or higher technical schools and that practically all have been successful in chemical work.

HOLLOW BUILDING TILE GROWING IN FAVOR.

Hollow building tile, in common with other structural products, decreased in quantity and value in 1918, but its decrease in value was smaller than the decrease in the value of any other structural materials except fancy brick and enameled brick, which are minor products.

The output in 1918 was 1,964,000 tons, valued at $12,980,000, which, when compared with that in 1917, 2,590,028 tons, valued at $13,255,433, shows a decrease of 626,000 tons, or twenty-four per cent, in quantity, and of $275,000, or two per cent, in value. Hollow building tile was used by the Government in large quantities in 1918 and its greatly increased use in the future seems assured, as it is not only desirable material for use in partitions and floors in large buildings in a city, but for use in dwellings, barns, silos, and other buildings in the country.

AMERICAN MANUFACTURERS DESIRE THE METRIC SYSTEM.

It is the opinion of the manufacturers of the State of Washington that metric units of measurement should be used in the United States. A referendum vote just conducted by the Manufacturers' Association of Seattle showed a 2 to 1 majority in favor of meter-liter-gram, the metric standards.

Following is a copy of the resolution sent by them to President Wilson: "In order that you may have knowledge of the interest taken by the manufacturers of Washington and sentiment with reference to changes which should be made in our system of weights and measures, we advise you at this time that the result of referendum taken among the manufacturers of this state shows that they are 2 to 1 in favor of the adoption of the meter-liter-gram or metric system."

"We believe that this system will eventually become the standard the world over and hope that you will use your good offices to establish it at the earliest possible time in the United States.—[Manufacturers' Association of Washington."

This resolution is typical of those which are being received daily at Washington, D. C., from engineers, manufacturers, and men of every profession all over the United States.

Digitized by Google

A FEW LIVE PROJECTS IN HIGH SCHOOL MATHEMATICS.

By Frank M. Rich,
School 19, Paterson, New Jersey.

In the course of a friendly chat the other day, a fifteen year old boy, who attends what I take to be a fairly typical high school, voiced a criticism of his instruction in algebra and geometry, so modest and kindly and withal so sensible, that I cannot help wishing his teachers had been there to hear.

Perhaps when we get school management sufficiently democratized, so that students are free to express their views, when they have them, we shall be able to get the additional benefit of the good horse sense that these youngsters occasionally display.

"If the teacher would only spend one day," he said, "take just one recitation period to show us some of the ways this stuff could be used by each of us in real life, I think it would be a big saving of time in the end. One period wouldn't be much, and yet it would probably be enough to answer the question that a lot of us always ask ourselves, especially when the work does not go very well, 'What's the use of all this drivel anyhow?' "

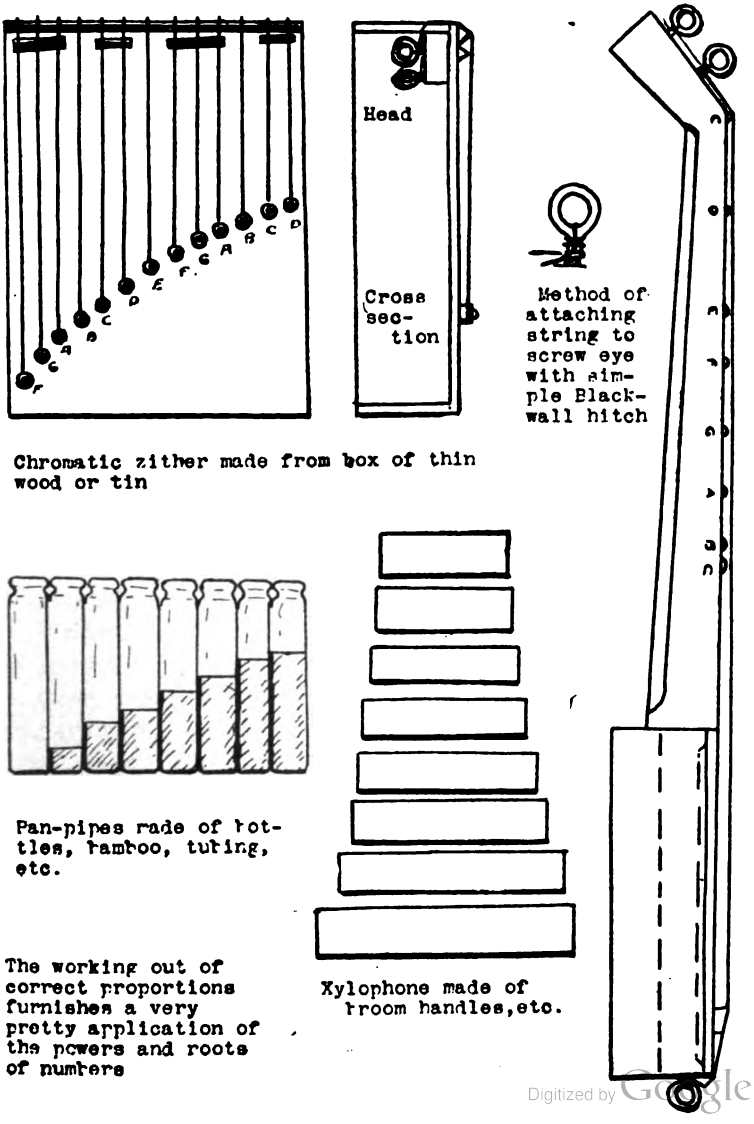
A critic less kindly and modest might have maintained that a teacher who failed to take one day and every day to show very concretely and personally what the subject matter is good for, was a pretty poor kind of instructor. For, as an ordinary selling proposition, the first step would naturally be to make the goods seem to the purchaser something eminently worth while. But the fact remains that motivation as it applies to high school mathematics for the average youth has not got very far, and a few instructors insist, like the cowboy when he saw the giraffe, "There ain't no such animal!"

However, since boosting usually gets us farther along than knocking, let me suggest a few projects that I have found the source of considerable interest to boys and girls outside the schoolroom, with the hope that they will not be found less interesting inside. One is the application of algebra in the making of home made musical instruments. The other an application of geometry in the adjustment and use of a theodolite that most high school boys and some high school girls will be able and willing to make. I do not expect that all, or even a majority of the students will be carried away with these ideas. The list is too small to meet everybody's taste. But if only one or two wish to try them, and will bring their results to class for explana-

Digitized by Google

tion and discussion, I believe that the socialization of the recitation, the injection of an element of possessive and personal interest, the extension of the method to include a very much wider range of projects to meet other interests, will in time make a decided difference in the attitude of the average student toward these subjects. Perhaps also the possible correlation with physics, mechanical drawing, manual training, music and composition will be worth consideration.

HOME MADE MUSICAL INSTRUMENTS


Head
Cross section
Method of attaching string to screw eye with simple Blackwall hitch
Chromatic zither made from box of thin wood or tin
Pan-pipes made of bottles, bamboo, tubing, etc.
The working out of correct proportions furnishes a very pretty application of the powers and roots of numbers
Xylophone made of broom handles, etc.

Digitized by Google

The Chromatic Zither.

Almost any box of thin wood or even a square pan or rectangular oil or varnish can, cut in two, can be made into a rather sweet toned zither. By arranging the tuning pegs inside the box, and placing one fret across the end, the chromatic scale can be played with only eight strings. In addition to a can or box for the body, the materials needed will be a strip of wood for a "head" into which the keys are inserted, about ½ by 1½" by the width of the instrument, medium heavy screw eyes for keys, fine steel piano or mandolin wire for strings, and if the body is of wood, triangular strips of wood for bridge and frets, and small screws and washers for fastening the strings to the "belly." If tin is used for the body the strings will be fastened with solder, and heavy wire of two sizes used for bridge and frets. The construction can be readily inferred from the diagram. It is the mathematics that mainly concerns us here.

How long should each string be, so that with uniform tension and with uniform wire they will play in tune? Where should the fret be placed to raise the pitch of each string exactly one half step? The answer is a very pretty application of the roots of numbers. Whatever the length of C, C ♯ will be a certain fraction of that length. D will be the same fraction of C ♯, and so on with the remaining ten steps of the chromatic scale. Call this fraction x. When we reach the octave above, or in other words, when we have multiplied this fraction by itself 12 times, the string will be just half the length of the string we started with, and we have the equation:

$$x^{12} = 0.5$$

Solving:
$$x^6 \text{ or } F\sharp = \sqrt{0.5} = .70710678$$
$$x^3 \text{ or } D\sharp = \sqrt{0.70710678} = 0.840896$$
$$x^2 \text{ or } D = \sqrt[3]{0.70710678} = 0.891$$
$$x \text{ or } C\sharp = \sqrt[3]{0.840896} = 0.944$$

The remaining powers of x can easily be got by multiplication, and the strings proportioned accordingly.

The Samisen.

Another stringed instrument, easy to construct of wood or tin, is a kind of banjo or samisen, shown in the cut. A cigar box or tin pan will do for a body, and for the "neck," a broomhandle or a strip of inch board, bevelled for a "head" where the screw-eye pegs are inserted, planed smooth for a "finger board," care-

Digitized by Google

fully fitted to holes in the box, the box flush with the fingerboard, and finally cut away under the "belly" to allow free vibration, and fastened with another screweye, which also serves as a "tailpiece" to hold the other end of the strings. Thumb tacks serve as "frets" on the fingerboard. A small bridge of hard wood, slightly higher than the frets, is placed near the head, and a taller one, two inches or so from the tailpiece. The upper bridge is slotted for the two strings, and the slots should be deep enough so that the strings will come near enough to the frets to be "stopped" or pressed down with the merest touch, and yet not near enough to touch when the string is played "open."

The mathematical problem, in this case, is to locate the frets, in much the same manner as the length of the zither strings was computed. The only difference is that in this case the location of the twelfth fret may be a trifle less than half way to the lower bridge, as the tension of the string is increased a little in fingering and this has a tendency to sharp the tone and would need to be offset by setting the frets slightly higher. Locate the twelfth fret by experiment and determine the difference in location due to increased tension in fretting. Subtract this difference from the theoretical location of each string.

The Xylophone or Glockenspeil.

Bars of wood, strips of glass, lengths of pipe, etc., suspended or laid across two supports in such a way that they have some freedom of vibration give a musical tone when struck with a light mallet. The xylophone, glockenspeil, orchestra "bells" and a number of other musical instruments are constructed on this principle. Pipe, broom handles, curtain poles, window glass, hard wood moldings, in fact a variety of material of uniform cross section can be utilized for home made instruments of the xylophone type.

If the other dimensions of a vibrating bar were proportional to the length, the same law of pitch that applies to strings would apply to bars—half the length gives twice the vibrations and hence the pitch of the next octave above. But when the bars are cut from uniform material, the diameter is not proportional to the length. The smaller bars are disproportionately thick, and the thicker they are, the stiffer they are, and the more rapidly they vibrate. Hence a bar of the same thickness but half the length of another would sound more than an octave above it. In getting the dimensions, find by experiment the length which

Digitized by Google

gives the octave above and use this ratio for the value of x^{12} in the equation, and work it out as above.

Pan Pipes.

Every boy knows the musical joy to be extracted from an empty bottle, shot gun cartridge or stopped tube of any sort when blown across. A row of such tubes of the right length fastened together in a row, makes the familiar Pan-pipes, which might fit in acceptably to a collection of home made instruments. Joints of bamboo, bottles partly filled with putty, pipe or glass tubing corked at one end, etc., furnish available material for a set. The laws governing the lengths are similar except that x^{12} is considerably less than .5 for reasons connected with the curious effects of mouth pieces upon the rapidity of vibration.

The Home Made Transit.

Articles on elementary surveying in several popular boys' books such as The Scientific American Boy at School (Munn and Co.) The Boy Mechanic (Popular Mechanics), and the Boy Scout Manual, would seem to indicate that this sort of work makes a wide appeal, at least to boys. My experience is that girls are equally interested. Certainly there is very little in geometry to appeal to the interests of the average student apart from some concrete, utilitarian outdoor application. But most of the apparatus recommended in articles I have seen is of the crudest sort, not calculated to give results of any practical value. It is only when a class has access to a real theodolite, and learns to use it practically, for friends and neighbors, measuring the lumber in standing trees; measuring inaccessible heights and distances; laying out grounds, roads and gardens, and making accurate maps of them; locating the stars and planets from tables in the almanac; making the necessary measurements for ditches to drain land, carry off snow water, etc.; computing the labor in digging cellars, filling in grounds, blasting ledges; it is only when a class can make the old folks sit up and take notice, and do a piece of work for which somebody is much obliged, that the study begins to fill a real place in the students' lives. In every locality and on almost every piece of property, there is engineering work to be done, not important enough to hire a salaried expert, but valuable enough to be a worthy present from the class or student to the neighbor or the neighborhood that receives it.

This sort of work with a good companion or two, in the open

Digitized by Google

country is as good fun as hunting or boating or golfing, and best of all, there is the added satisfaction of doing somebody else a good turn.

Of course it will not be expected that such an instrument as we describe will do the work of a two hundred dollar transit. Neither should it be dismissed as entirely useless. It is adjusted and operated much the same as the professional instrument, and if carefully made and used, at least on coarse work, should give results that are worth while.

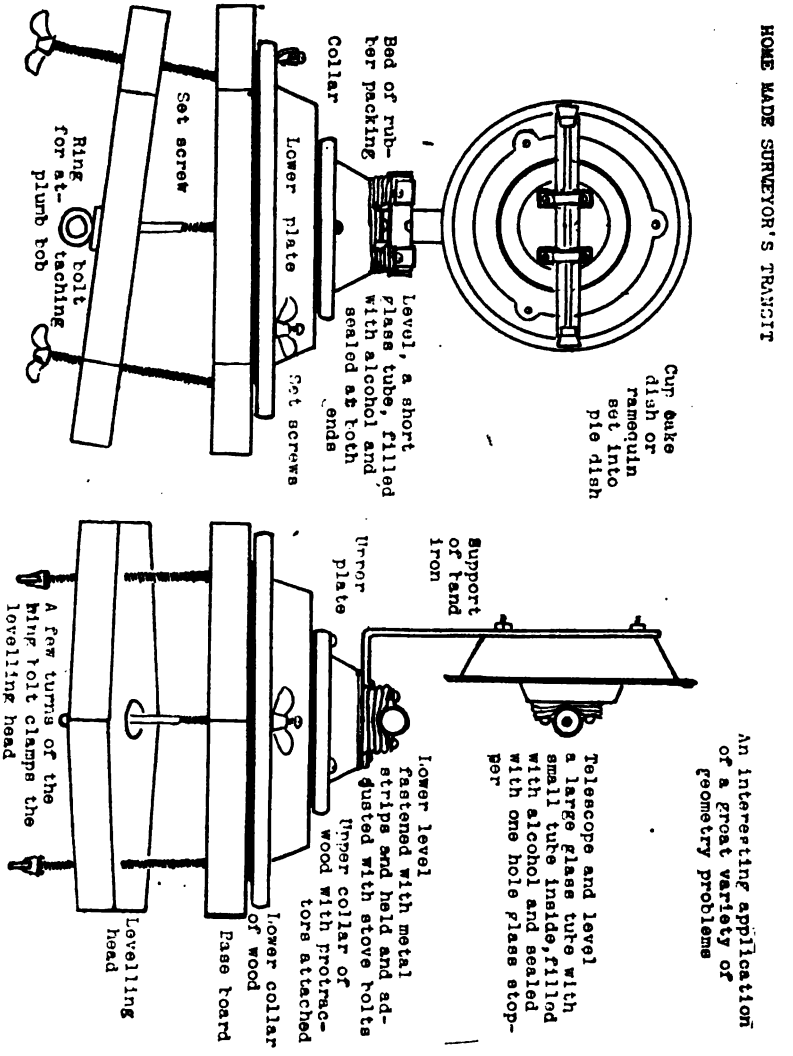
Before starting to make the transit, a student should look up "theodolite" in the encyclopaedia—preferably the Encyclopaedia Britannica—and read a general account of the instrument and its use. A good pocket manual—such for instance as Tracy's Plane Surveying (John Wiley and Sons)—is a necessity.

The materials needed are two cup cake pans (muffin pans or ramequins) preferably of granite ware, so as to be inflexible; two small pie pans of the same material and a trifle shallower than the cup pans; a foot or so of band iron, 1″ by ⅛″; one and a half dozen round head stove bolts, ¾″ long; three 2″ round head bolts with wing nuts; one 4″ ring bolt; three 3″ set screws; a few washers to fit the stove bolts; three heavy 3″ T hinges with short screws; some strips of tin or other sheet metal; a 6″ piece of glass tubing, ¾ to 1″ in thickness, preferably not absolutely straight, but taken from a piece that has a barely perceptible curve; two one-hole rubber stoppers to fit the tube; an absolutely straight 6″ piece of small glass tubing to fit the holes of the stopper; a 2½″ piece of glass tubing, size immaterial, with plain rubber stoppers for both ends. This glass, like the first, is to be used for a level, and should be cut from a slightly curved strip, so that, when filled with alcohol, the bubble will not shoot too suddenly from side to side when the instrument is adjusted.

The remaining materials are some pieces of clear, 1″ board; some very sound firm ½ or ⅜″ stock; three good broom handles, or other stout pieces, for tripod legs; a 10c plumb bob and cord; four pasteboard protractors, sold by school supply houses at 30c a dozen, or obtainable by taking photographic prints of 4″ celluloid protractors; a quantity of rubber packing (an old hot water bottle will do) and some bits of adhesive electrician's or "friction" tape. If the hinges obtainable are not very tight, it will be better to rely on home-made hinges, made by screwing narrow blocks to the under side of the levelling head; splitting

Digitized by Google

each leg with a saw far enough so that the block can be inserted in the split, and the whole made tight by thrusting a short bolt through a tight fitting hole, placing washers at each end, and screwing the nut as tight as necessary.


HOME MADE SURVEYOR'S TRANSIT
Ring bolt for attaching plumb bob
Set screw
Lower plate
Collar
Bed of rubber packing
Level, a short glass tube, filled with alcohol and sealed at both ends
Set screws
Cup cake dish or ramequin set into pie dish
An interesting application of a great variety of geometry problems
Telescope and level a large glass tube with small tube inside, filled with alcohol and sealed with one hole glass stopper
Support of hand iron
Lower level fastened with metal strips and held and adjusted with stove bolts
Upper collar of wood with protractors attached
Lower collar of wood
Base board
Levelling head
A few turns of the ring bolt clamps the levelling head

Cut the rings of thin wood and smooth them up with a file so that the hole will just fit the widest part of the cup pans, not counting the rim. Make the rings of packing of corresponding size, except that the center hole in the packing is a little smaller, so as to grip the pan a little and insure a snug fit. Work out

Digitized by Google

the hole till it is just right. When the ring is loosened a trifle, the pans should turn easily, without play; but when the rings are pressed down tight, the packing should meet the pan rim and clamp it firm.

Glue the protractors to the small rings, using the greatest care to measure with the compass and join and center the protractors perfectly. Drill snug holes, 120° apart in the rings, and corresponding holes in the pans and baseboard to which they are attached.

Saw out the hexagonal baseboard and levelling head. The upper surface of the baseboard must be absolutely true, as any curve here will throw the telescope off the true level, and greatly increase the inaccuracy of measurement. Bore a tight hole in the baseboard for the ring bolt. The hole in the lower board will have to be looser, and reamed out, so as to make a conical hole that will allow the levelling head to be tipped somewhat. The levels rest on beds of rubber packing and are held firm by hangers of sheet metal as shown in the diagrams. A little calculation will be necessary to get the band iron bored and bent so that the "telescope" can be turned completely around, just clearing the lower spirit level, and swinging in the exact axis of the instrument.

In assembling the various parts, they will have to be put together in a certain order. Screw the legs to the levelling head. Put the levelling screws in a little way. Put one of the smaller collars with its lining of rubber packing on the lower cup, and the larger collar on the large pan. Bolt the band iron support to the cup, putting a washer made of packing on the bolt between the iron and the pan, and another made of friction tape between the pan and the nut. The first washer is to allow of fine adjustment of the iron support, and with it, the upper graduated circle, so that the telescope will swing up and down in a plane exactly vertical. The band iron support, however carefully bent, will probably be slightly more or less than 90°, and slight inaccuracies can be rectified by screwing one or the other of the nuts very tightly against the packing. Both will need to be very tight, however. The packing between the pan and the nut is simply to keep the nut from turning when the screw is adjusted from above. The thinner it is the more rigid it will make the support.

Attach the short level with its deep bed of packing to the lower cup, using friction tape next to the nut as before. Do

Digitized by Google

the same with the nuts which fasten the small collar to the pan. Fasten the larger collar by screwing the 2 inch bolts firmly into the baseboard, then clamping the collar with the wing nuts.

Fasten the upper pan to the iron support; put the remaining collar over the cup, attach the long level, using less packing than with the short; fasten the upper collar; set the instrument on the levelling screws, fasten with the ring bolt, and the instrument is ready for adjustment.

Adjusting the Transit.

Begin with the plates and the bubble tubes for levelling the instrument. When these are in perfect adjustment, the bubble tube and the plates are parallel, and when the levelling head is truly horizontal, the bubble remains in the center of the tube whichever way the plates are turned. Our problem is to screw the bolts holding the bubble tube so that when it is level the plates are level.

All parts of a transit are adjusted by rotating them and noting the effect of each rotation. It is plain from the diagram, that a level, with one support longer than the other, might stand with its bubble in the center when the plates were out of horizontal. But the moment the plates are swung round, the bubble runs to one end. Adjust the levelling head, so that the bubble remains in the same end of the level throughout the revolution, then take up the screws on the upper end of the level till the bubble again rests in the center of the tube. Rotate, as before, and bring the plates nearer to horizontal; then take up (or let out) the proper screw to true up the level. Continue the process till the instrument is in adjustment. The level itself will need to be rotated so that the curve will be up in the center, otherwise the bubble can never be brought to rest in the proper position.

The "telescope" must be adjusted so that it moves in a plane perpendicular to the levelling plate, and parallel to the plate to which it is attached. It can be made parallel to its own plate by sighting it on a given target, then turning it over vertically, end for end (called by surveyors "plunging the telescope") and adjusting the screws, a little at a time, till the sight falls on the same point, whichever end is looked through.

The vertical plane is adjusted by levelling the transit, sighting the telescope on some approximately vertical line—the corner of a building, for instance—moving the telescope up and down

Digitized by Google

and observing how it coincides with, or cuts, the line it is sighted upon; then turning the telescope around horizontally, and sighting with the other end in the same manner. If, when reversed, the telescope traces a line that cuts the line it is sighted upon in the opposite direction, it is plain that the bolts in the support need adjustment till the lines coincide, or cut in the same direction and at the same angle, whichever end is looked through.

Having the plates and levels in good adjustment, make a mark on the upper cup opposite the 0 on both sides of the graduated circle, so that when the telescope is depressed or elevated, the line will register the angle above or below horizontal. A similar mark is needed on the lower cup.

Horizontal angles are read by turning the upper plate till the line is on 0, then turning the lower plate, upper plate and all, till the telescope is sighted on one line of the angle; then clamping the lower plate firm with the wing nuts, and turning the upper plate till the telescope rests on the other line of the angle. The mark on the plate registers the number of degrees. Considerable accuracy can be attained in reading horizontal angles by repeatedly turning the lower plate back to the first line (back sight) then clamping and turning the upper plate to the other line (fore sight) allowing the readings to add themselves on the graduated circle; then dividing the sum of the angles turned by the number of times the angle was taken, which is the average of several observations, and much more accurate than any single reading is likely to be.

Tape, Rod and Stadia.

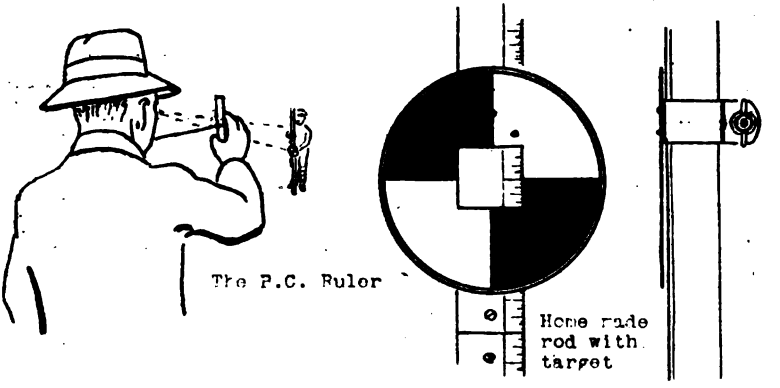
In connection with the transit, one needs a tape or chain for measuring horizontal distances, a rod for measuring vertical distances, and a stadia for estimating distances without actual measurement.

The best tape, of course, is the regular 100 ft, steel surveyors' tape, but these are expensive. The ordinary 100 foot cloth mechanics' tape will do, but they stretch more or less, and soon wear out. Even this may not be available, and the young surveyors will have to make substitutes of their own. If they can get the loan of a good steel tape to copy from, they can make a very good one out of a little over 100 feet of iron wire, 18 gauge or larger, preferably galvanized.

Take the tape and wire to a level roadway. Bend the wire into a ring at the end for a handle. Drive two stakes close together, and fasten the ring ends of both tape and wire to them.

Digitized by Google

Draw both tight with a stress of 6 pounds. At each foot, flatten the wire a little by hammering, and make a tiny hole with a centering punch or other sharp steel and label the number with Roman numerals stamped very lightly with a cold chisel. The first foot should also be divided into tenths, and possibly into hundredths.



The rod can be made by screwing a number of rulers or yard-sticks to battens as long as one can reach—say seven or eight feet, marking the feet with good sized calendar numbers glued on. Surveyor's rods, like the tapes, are marked in tenths and hundredths of feet, for reason that will be appreciated especially in work with the stadia. The ordinary marks can be readily changed to decimal readings if we remember the aliquot parts of 100; $6'' = 1/2 = .50$; $2'' = 1/6 = .16\frac{2}{3}$; $1'' = 1\text{-}12 = .08\frac{1}{3}$ and $1/8''$ is practically the same as .01 of a foot.

A movable target, made of a pie tin, or 6" circle of sheet metal is a convenience. In the center cut a square hole the width of the rod. Above the hole rivet a strip of metal that will encircle the rod and clamp with a bolt and wing nut, to hold the target in place. As an aid in sighting at a distance, the target should be divided into quarters, and two of the quadrants diagonally opposite painted in some conspicuous color.

The stadia in the telescope of a professional transit is an ingenious device for estimating distances without actual measurement. It depends upon the principle that the apparent diameter of an object is inversely proportional to its distance, or in other words, the farther away an object is, the more of it can be seen between lines a given distance apart and a given distance from the eye. A good substitute for wires in the telescope will be a device used by artillery officers called the battery

Digitized by Google

commander's ruler. Paste to a short piece of wood or tin, a strip of the quadrille ruled paper commonly used for graphs. Make a hole in the center of the stick and knot in a stiff string. Stretch tight and tie a knot carefully at a certain distance from the stick. If the paper is quarter inch ruled, the distance should be 25 inches. If the paper is divided into tenth inch squares 20 inches is a good length. Take the knot in the teeth, hold the stick vertically as far away from the eye as the cord will permit, and the same distance from the eye as from the teeth. A quarter inch square held 25 inches from the eye is of the same apparent height as one foot placed 100 ft. from the eye. If we sight across this simple instrument at the rod set up 100 ft. away the lines on the paper will coincide with the foot marks on the rod. If the rod is set back to 200 feet away, the squares apparently cover 2 feet on the rod; if brought up to 50 feet, the lines mark .50 ft. and so on. The distance from the eye to the rod will always be 100 times the number of feet that one space will cover. Such measurements cannot be read accurately enough for fine work, but are useful for mapping unimportant points, etc.

Having taken so much pains to construct a transit, what shall the student do with it? The answer will depend largely upon individual circumstances. One may wish to dam a brook and make a small pond; another wishes to make ditches and drain a bog; one needs to measure a flag pole for a new rope; another to know whether the old tree he purposes to cut will smash the fence in falling. One is willing to find out for a neighbor whether he can do away with his cesspool, and run a sewer to a nearby stream; another to measure and map a friend's farm. A good many will wish just to amuse themselves measuring objects from a distance, finding stars, and so on. Whether it is laying out a flower bed, or tunnelling a mountain, the transit will be found interesting and useful, and not least in interest and usefulness are the habits of scientific, accurate procedure which is the faith that literally removes the mountains.

CORRECTIONS.

The article "Biology and the War" on page 714, Nov., 1919, Vol. XIX, should have been credited to Oren E. Frazee, Normal School, Saint Cloud, Minn.

The article "Some Suggestions for a General Science Course" on page 773, Dec., 1919, was received for publication on March 8, 1917. We were not informed, until after this was printed, that the author did not wish it published. We apologize for its appearance. It is a good paper, however,

Digitized by Google

APPLIED MATHEMATICS FOR HIGH SCHOOLS.[1]

By Eugene H. Barker,
Polytechnic High School, Los Angeles, California.

For a number of years there has been a very manifest feeling of unrest and dissatisfaction among teachers of high school mathematics concerning the content of the course as now organized. From time immemorial the first year has been given over to a treatment of the traditional algebra in the traditional way, with its multiplicity of pestiferous and uninteresting so-called "problems," all too artfully and villainously contrived, but having absolutely no connection with the child's past experience, present interest or future prospects.

This is customarily followed in the second year by a painstaking study of a collection of formal proofs of theorems in geometry, interesting to the mathematician and the logician, but a dreadful task for the uninformed novitiate.

While this two-year treatment of algebra and geometry has its merits, may there not be some selection, some eliminations, some re-arrangement of material possible, which, while just as much educational in value, can be turned to practical account in the student's daily life?

For time out of mind it has been the custom at learned conventions of pedagogical highbrows to deprecate in a vague sort of way the lack of a proper coordination between the schoolroom lesson and the practical problem as it arises in the household, on the farm, in the shop, or at the office.

It is not my present purpose to discuss the *desirability* of a course in applied mathematics, for I think we are all agreed that such a Course *is* desirable. Nor shall I indulge in vague generalities or pedagogic theories. Instead, I shall cite actual specific problems which possess at the same time interest for the student and have a practical value.

These six things a practical course in applied mathematics must compass; namely,

1. An adequate treatment of the fundamental operations of arithmetic with proper attention to modern methods of performing these operations.

2. The cultivation of the ability to judge a computed result as to its *reasonableness.*

3. A sufficient acquaintance with the symbols of algebra

[1] Delivered before the Mathematics Section of the California Teachers Association, at Berkeley, October 15, 1919.

Digitized by Google

and of algebraic operations to enable the student to interpret and apply simple algebraic formulas.

4. A sufficient knowledge of geometry to enable the student to compute the areas and volumes of the commonly occurring geometric figures.

5. Some facility in the use of tables.

6. The ability to read a graph.

The field of graphical representation affords wonderful opportunities and possibilities and should be treated at considerable length.

It frequently happens that an idea can be expressed very much more clearly and briefly by a drawing than by words. Thus, the idea of a square is conveyed instantly by a picture of a square, □. The drawing or diagram is called a graphical representation. Many illustrations of this sort will be doubtless already familiar to the student. Tally marks, 𝍸 the indication of the hours on the clock-face by the numerals I, II, III, IIII, etc., the determination of the pitch of a note by its location on the musical staff, , the crescendo sign, diminuendo, , etc., are all graphic in character, as also are the indication of direction by an arrow, ⟶ the north and south line, , conventional signs used in map drawing, like for railroad, for grass, astronomical symbols such as ⊕ for earth, ☾ for moon, the symbols of geometry. △ for triangle, ⊙ for circle, and the like.

A geographical map is an example of line representation wherein distances are plotted to some convenient scale. In every case the scale used will depend upon the amount of territory to be shown and on the desired size of the map itself.

Line representation is the basis of drawing and of all mechanical work. The floor-plan of a house, for example, and its elevation, are graphical representations of the location of walls, doorways, windows, etc.

Such data as the valuation of exports, imports, increase in population, relative lengths of rivers, heights of mountains, changes in temperature, amounts of rainfall, variations in the price of food-stuffs, and the like, can be presented much more effectively by means of diagrams than by columns of figures.

A relation like that which exists between the speed of a vehicle and the time consumed in traveling one mile is best shown diagramatically.

Digitized by Google

Graphic diagrams are of a great variety of forms, and in determining upon the scheme of representation to be used in a particular case, the student should select that type which will set forth in the most telling fashion the essential facts of the data to be presented.

Abundance of material suitable for graphic representation can be found in such publications as the *Statistician's Yearbook*, *World Almanac*, *Tribune Almanac*, *Scientific American Reference Book*, and any geographical-statistical atlas. Much material of this kind can usually be obtained from the local Chamber of Commerce, Bureau of Mines, Development Board, the newspaper offices and the banks. A great variety of types of graphical representation will be found in various magazines, especially those devoted to engineering and construction work. Indeed, scarcely a book or technical article is written these days wherein the author does not have recourse to pictorial charts or diagrams.

The use of tables is a subject to which especial attention should be given. There are certain calculations which occur so frequently that to save time and labor their results have been tabulated. For example, the circumferences and areas of circles of various diameters, the square roots of numbers, the decimal equivalents of common fractions, etc., have all been arranged in tabular form in much the same way that multiplication tables are arranged, or as railroad time-tables are arranged. These tables are not ordinarily memorized as the multiplication table is, but are consulted or referred to each time need arises for a particular result.

For example, if one wants the square root of 20, he does not actually extract the square root but refers to a table of square roots and finds it to be 4.4721. Or if he desires to know the area of a circle whose diameter is 50, he refers to a table of areas of circles and finds it to be 1963.5. Or again, if he desires to know the interest on $350 for two years and six months at eight per cent, he refers to an interest table and reads his answer instantly, $70.

Just what tables one needs most, depends upon one's occupation. The machinist has use for tables of decimal equivalents of common fractions, tables of cutting speeds, etc. Draughtsmen and designers use tables of strengths and weights of various materials, standard proportions of machine parts, etc. The actuary uses mortality tables, the banker, interest tables, the

Digitized by Google

merchant, discount tables, the electrician, wiring tables, etc. The professional computer has need for all of these and many more.

There are certain mathematical tables, however, which are of general value, whatever one's occupation. Among these are tables of squares, cubes, square roots, cube roots, decimal equivalents of fractions, and logarithms of numbers. The table in most common use is the multiplication table.

It is a simple matter to familiarize students with the commonly occurring formulas of mechanics.

What boy in the class will not manifest an interest in the solution of such a problem as the following?

From the equations $s = \frac{1}{2} gt^2$ and $v = gt$, find the time it takes a pole-vaulter to reach the ground after he has cleared the bar at 13 ft. 2½ in., and find the velocity with which he hits the ground on descending.

A knowledge of ratio is essential to a proper understanding of the mathematics of industrial and mechanical pursuits. For example, mechanical advantage is defined in terms of ratio; specific gravity is defined in terms of ratio, and such expressions as gear ratio, and coefficient of expansion are of frequent occurrence.

There is no lack of suitable material for class-room work, suitable in point of interest and suitable in point of practical applicability. In the field of mechanics there are such problems as these, for example:

If a spindle tapers one sixteenth of an inch to the inch, what is the amount of taper per foot?

If a mechanically operated hack-saw makes 90 strokes per minute, what is the number per hour?

The driving pulley on a shaft is 42 inches in diameter, and makes 200 revolutions per minute. How many revolutions per minute will the driven pulley make if its diameter is 3 feet?

If steel expands 0.000007 of its length for each degree increase in temperature (Fahrenheit), how much will a 30 ft. steel rail increase in length when heated from 32 to 130?

Given the materials for a paving mixture as follows: 1 part of cement; 3 parts of sand; 6 parts of crushed rock; where a sack of cement is equivalent to about 1.3 cubic feet and a wheelbarrow load of material to about 4 cubic feet. If all the materials necessary for the mixture are to be dumped every 30 feet, how much of each material should be dumped at each place, if the

Digitized by Google

street is 40 feet wide, and the paving mixture is to be laid 5 inches deep?

Who will question the practical nature of the problem just cited? Who will say that it is not concrete?

In closing I submit an even dozen other typical problems from a variety of fields, commercial, industrial, agricultural, mechanical, and invite your attention to their practical character.

1. If a map is drawn on a scale of 100 miles to $\frac{3}{4}$ of an inch, what distance is represented on the map by $\frac{5}{16}$ of an inch?

2. If 400 cubic feet of stacked hay weighs one ton, find the weight of a stack 22 feet by 40 feet by 24 feet?

3. A certain school district voted $15,000 to erect a new schoolhouse. The assessed valuation of the property in the district was $750,000. Find the rate of taxation.

4. Two pulleys have their centers 20 feet apart; their diameters are 26 inches and 24 inches. What length of belt is required to connect them?

5. At 30 cents per running foot, what is the cost of a roll of belting of 16 turns, with outside diameter 2 feet; inside diameter 20 inches?

6. If the standard 150 yard target has a bullseye 8 inches in diameter, what should be the diameter of a bullseye which will appear the same size at 25 yards?

7. Prepare a diagram setting forth graphically the following facts. Of the persons who have attained sufficient distinction to be listed in "Who's Who in America," 71% were college trained; 16% had high school training; 9% stopped after the grammar school; 3.8% were prepared by private tutors, and .2% are self made.

8. If the weight of oak ashes is .03 of the weight of the wood burned, and the weight of carbonate of potash contained in the ashes is .065 of the weight of the ashes, how many pounds of carbonate of potash are there in the ashes of 1 cord of oak, if stacked oak wood weighs 2 tons per cord?

9. A shaft has upon it two pulleys, each 8 inches in diameter. The speed of the shaft is 400 revolutions per minute. What must be the sizes of the pulleys of two machines, if when belted to the shaft one of them has a speed of 300 revolutions per minute and the other of 900?

10. A sugar factory consumes on an average 3,000 tons of beets per day. If 75 per cent of the sugar in the beet is extracted how many tons of sugar are produced per day from beets containing 15 per cent of sugar?

Digitized by Google

11. An automobile is bought for $1,000, run for 4 years, and sold for $750. During that time the cost of gasoline and oil average $.75 a day; repairs, including tire expense, amounted to about $25 a month; license $15 a year, and insurance $25 a year. What did the automobile cost per day?

And in order that I may leave a good taste in your mouth, I submit, as No. 12, this problem:

12. If a circular cake 7 inches in diameter and 3½ inches high, sells for 50 cents, what will be the probable price of the same kind of cake 16 inches in diameter and 8 inches high?

Surely there is no lack of material for practical problems and the time is ripe for reform. My prediction is this, that inevitably, and soon, the traditional high school algebra and geometry will give way to a single course in applied mathematics.

PLATINUM-BEARING GOLD PLACERS OF THE KAHILTNA VALLEY.

The Kahiltna Valley, Alaska, including the basins of Cache and Peters creeks, was visited in the fall of 1917 by J. B. Mertie, Jr., whose report on his work has just been published in the Survey's Bulletin 692-D. Mr. Mertie gives a geologic sketch map of the region, describes its geography and geology, and presents an account of its mineral resources, which includes descriptions of the placers on many creeks. Though gold is the only mineral thus far recovered in commercial quantities the placers have yielded small quantities of other valuable minerals, which include platinum and ores of tin and tungsten.

DETERMINATION OF THE BROCARD POINTS.

By J. Carl Kamplain.

Student, Crane Junior College, Chicago.

I have read the methods of determining the Brocard points of a triangle which were published in School Science and Mathematics for May, 1918, as solutions of problem 555. I should like to submit the following solution which I think you will find simpler than any which were published at that time. As far as I know this method of construction has never been published.

In $\triangle ABC$, to find P_1 and P_2 such that $\angle CAP_1$ $(ACP_2) = \angle BCP_1$ $(CBP_2) = \angle ABP_1$ (BAP_2).

Construction for P_1:

Draw Cw and Az intersecting at D, and By intersecting Cw at E, so that $\angle ACw = \angle C - \angle CAz$ and $\angle CBy = \angle B - \angle BCw$. P_1, the point of intersection within the triangle of the circles circumscribed about triangles ACD and BCE, respectively, is the point required.

Proof.

By principles of elementary geometry, $\angle AP_1C = \angle ADC = 180° - \angle C$, and $\angle CP_1B = 180° - \angle B$. Therefore $\angle AP_1B = 180° - \angle A$.

Therefore, $\angle P_1CB = C - [180° - \angle P_1AC - (180° - C)] = \angle P_1AC$.

Likewise $\angle P_1BA = \angle P_1CB = \angle P_1AC$.

Similarly for P_2.

Digitized by Google

INTRODUCTORY COURSES IN BOTANY III.

By Bradley M. Davis,

University of Michigan, Ann Arbor.

(Continued from December, 1919.)

Outline No. 7.

A High School Course.

1. Gross morphology of any common plant.
2. Rapid survey of the chief groups of the plant kingdom to develop the idea of classification. Gather types in the school garden or vicinity, or have types growing in the laboratory. Division, class, order, family, genus and species.
3. Comparative study of bean and corn. Plants, seeds and seedlings. Life cycle.
4. Study of protoplasm in plant and animal cell. Spirogyra, Amoeba, Elodea, onion skin or other simple tissue.
5. Careful study of the morphology and physiology of a seed plant. Emphasize the relations between structure and function.
6. The leaf. Activities discovered by experiment, structure then studied.
7. The root. Structure and function, osmosis, capillary action, root pressure, relation to soil. Conditions necessary for health, air, water, physical conditions of soil.
8. Stems. Types and function, some study of comparative structure.
9. Buds. Structure and functions.
10. Flowers. Study of a few available types. Adaptations, pollination.
11. Fruits. Principal forms, structure and development, food relations.
12. Seeds. Types of structure, food storage.
13. Seedlings. History and conditions of development.
14. Reproduction. General considerations based on material studied. Asexual methods compared with sexual reproduction.
15. Plant breeding. Methods employed and results of economic value.
16. The weed problem. The struggle for existence, variation, survival, adaptations. Principles of organic evolution.
17. Plants of economic value. Emphasize the dependence of animal and human life upon plants, the dependence of the city upon the country.
18. Bacteria and other fungi. Study of the structure and life habits of a few forms. Relation to decay, the soil, animal and plant diseases.
19. Work of state and federal departments of agriculture.
20. Type studies to illustrate plant evolution if the length of course permits.
21. Plant communities. Field studies if time permits and if seasons and school conditions render practicable.

"My experience is that pupils are especially interested in plant activities and in structure studies showing adaptations. In a short course subjects 1–19 inclusive should be taken. Some of these topics may be dealt with lightly but 4–14, 16 and 18 should be the backbone of any course."

"In high school work careful study and selection of apparatus is necessary. In most cases botany precedes physics and chemistry and therefore simple lessons on oxygen, carbon dioxide, composition of air, soil, water, etc., are necessary before experiments on leaf activities are started. In every case preliminary lessons by the teacher must prepare the pupil to perform experiments or to understand demonstrations."

Digitized by Google

OUTLINE NO. 8.

A half-year course, ten hours a week, or a twelve weeks course fifteen hours a week.

1. Introductory. Definition and scope of the science. Why a study of plants is important.
2. Parts of a seed plant (chiefly a review of what has been learned in Nature Study in the lower schools).
3. The cell as the unit of structure and function. Protoplasm.
4. Vegetative functions of a seed plant, including the structure of the organs involved. (a) Transpiration. (b) Absorption of water. (c) Passage of liquids through the plant. (d) Nutrition, including gaseous exchange; the elaboration, translocation, storage, digestion, and assimilation of carbohydrates and proteins; secretion and the economic value of plant secretions (briefly); theories of crop rotation.
5. Fermentation and the nature and work of enzymes.
6. Respiration.
7. Growth.
8. Adjustment to environment.
9. Life history of the fern with discussion of methods of reproduction, alternation of generations, life cycle, inheritance (briefly), struggle and survival.
10. Life history of moss and liverwort.
11. Life history of some algal types.
12. Life history of some fungal types.
13. Economic importance of fungi, including plant diseases.
14. Saprophytism and symbiosis.
15. Sex.
16. Calamities and lycopods (briefly or optional).
17. Life histories of seed plants. Cycad. Pine. Angiosperm.
18. Plant families. Representative types, chosen with regard to their economic importance.
19. Theories of evolution, especially Darwinism and the Mutation theory.
20. Heredity with special emphasis on Mendelism and its practical bearings.
21. The evolution of plants through geological time (briefly or optional).

"Outside of technical schools, introductory courses should be planned, not primarily as introductory to more advanced courses in botany, nor wholly as a preparatory study for agricultural students, but as introducing the student to the nature of the subject, its materials, methods, aims, broader generalizations, history, unsolved problems, and its bearing on the student's own every day life; and especially on the supposition that the majority of the class may never take advanced courses. Emphasis, therefore, should be placed on the larger conceptions, broad general principles, and philosophical aspects of the subject. Relating the subject to the student's own life should be done chiefly with reference to its economic or commercial aspects, and especially to its cultural aspects."

"It should always be kept in mind that the course is in botany and not in horticulture, agriculture, plant pathology, market gardening, commerce, or in any other pure or applied science or art. This point of view is absolutely essential in consideration

Digitized by Google

of the best interests of the pupil and of any subsequent courses founded upon or closely related to botanical science. The aim of the course should be to give the student (1) a general survey of the science in its established departments, (2) acquaintance with general principles and problems, (3) introduction to the methods of science, and (4) preparation for courses in related applied sciences, such as horticulture, plant pathology, plant breeding, forestry, medicine, pharmacognoscy, etc. It is, of course, taken for granted that class discussions, lectures, and laboratory work will be supplemented by assigned readings in the adopted text or other books."

OUTLINE No. 9.

A half-year college course, eighteen weeks, six hours a week.

1. Introductory. History and importance of botany. Consideration of the seed plant as a whole.
2. The soil and its major constituents, with emphasis on the relations between plant and soil.
3. The principles of diffusion and osmosis. The intake of water and salts by the plant. The structure and function of root hairs.
4. The external and internal structure of roots and a study of the various functions assumed by roots.
5. Transpiration, with emphasis on the factors governing it and the importance of the process to the plant.
6. Photosynthesis. Its raw materials, apparatus, energy, and products.
7. The structure of the leaf, gross and microscopic, with particular emphasis on the function of each part.
8. Digestion and assimilation, with study of the main food types—carbohydrates, fats, proteins—and their importance to the plant. Enzyme action.
9. Respiration and fermentation, with emphasis on a study of the energy relations in the plant.
10. The stem of typical dicotyledonous and monocotyledonous plants, its structure and the part played by each tissue in the economy of the plant.
11. Wood, its structure and characteristics.
12. Growth as illustrated by a study of (a) some terminal growing point such as the onion root tip, and (b) the cambium, with an attempt to make the student visualize clearly the process of growth in plants.
13. The process of reproduction. The flower, its structures and their functions.
14. The fruit, seed and seedling.
15. The algae and fungi.
16. The mosses and ferns.
17. Principles of classification as brought out by actual work in plant identification by means of manual and keys.
18. Principles of inheritance. The theory of organic evolution.

"The primary object of this course is not to amass in the student's mind a wealth of knowledge relating to the whole plant kingdom and the various subdivisions of botanical science, but through the study of some typical seed plants, to enable him to appreciate the plant as a living organism. Structure and function are obviously so nearly interrelated that they are taken up essentially together, though the primary attack always

Digitized by Google

emphasizes function rather than the structural basis. Type studies, life histories, and homologies in the vegetative and reproductive structures of the various plant groups are largely avoided, though a very brief survey of the plant kingdom is made to enable the student to get a true perspective and to serve as a basis for a short consideration of the principles of evolution and classification."

OUTLINE NO. 10.

A twelve-weeks college course, three hours a day for five days a week. Given two days a week, the course would require a full year, or with four days a week it could be covered in a half-year. The three hour class period is divided between lecture and laboratory work as the subject requires. Each number in the outline represents a three-hour period.

I. STRUCTURE AND FUNCTIONS OF TISSUES.

First week.

1. External characters of stems, roots, and leaves. Leaf arrangement, especially in relation to light.
2. The cell. Cell wall, protoplasm, nucleus, chloroplasts, and vacuole. Function of chloroplasts with physiological experiments to show the products of photosynthesis.
3. Epidermis. Structure, with experiments to demonstrate its function.
4. Leaf tissues. A study from leaf sections of the structure and functions of its various parts. Experiment to show transpiration.
5. Parenchyma and collenchyma, and their functions.

Second week.

1. Tracheary tissue and tracheids, and their functions.
2. Wood and bast fibers, and their functions.
3. Sieve tissue and its function. Experiments to demonstrate some functions of vascular tissue.
4. Study of a woody stem to show arrangement of tissues, and annular rings.
5. Types of vascular bundles in stems, the open and closed collateral bundle, concentric and amphivasal bundles.

Third week.

1. Seed germination. The root cap and root hairs.
2. The radial bundle and the structure of the young root. Experiments to demonstrate osmosis and root excretion.
3. Food storage in stems, roots, and fruits.
4. Starch and aleurone. Experiment to show digestion of starch in seeds.
5. Meristem and mitosis.

II. REPRODUCTION.

Fourth week.

1. External features of the gametophyte and sporophyte of the fern. The sporophyll, sorus, sporangium, and spore.
2. The archegone and antherid of the fern.
3. Fertilization and the development of the embryo of the fern.
4. Microsporophyll, microsporangium, and microspore of the pine.
5. Megasporophyll, megasporangium, and megaspore of the pine.

Fifth week.

1. Male and female gametophytes of the pine.
2. Fertilization, and the development of the embryo of the pine. Significance of heterospory.
3. Microsporophyll, microsporangium, and microspore of a flowering plant.
4. Megasporophyll, megasporangium, and megaspore of a flowering plant.
5. Male and female gametophytes of a flowering plant.

Sixth week.

Digitized by Google

1. Fertilization, and development of the embryo of a flowering plant.
2. General review and summary of the life history of a vascular plant.

III. SURVEY OF THE PLANT KINGDOM.

3. Myxophyceae. Gloeocapsa, Oscillatoria, Rivularia.
4. Chlorophyceae. Chlorococcum, Ulothrix.
5. Chlorophyceae. Oedogonium, Spirogyra.

Seventh week.

1. Desmids and diatoms.
2. Red seaweeds. Nemalion and Polysiphonia.
3. Brown seaweeds. Ectocarpus and Laminaria.
4. Brown seaweeds. Fucus.
5. Bacteria. Their relation to decomposition, fermentation and disease.

Eighth week.

1. Mucor. A discussion of saprophytism.
2. Albugo and Peronospora.
3. General discussion of plant diseases with examination of illustrative material.
4. Plowrightia.
5. Smuts of corn and wheat and their economic importance.

Ninth week.

1. Wheat rust. Study of the life cycle with observations of the effect on wheat.
2. Gymnosporangium. Its life cycle and economic importance.
3. Mushrooms.
4. Puffballs.
5. General review of fungi and plant diseases.

Tenth week.

1. The moss gametophyte and sporophyte.
2. A liverwort.
3. The fern. A review of its life cycle and its position in the plant kingdom.
4. Lily and Iris.
5. Grass and sedge.

Eleventh week.

1. Buttercup and pink.
2. Crucifer and mallow.
3. Morning glory and mint.
4. Apple, cherry and pea.
5. Parsley and composite.

Twelfth week.

1. Identification and habitat of prairie plants. Field work.
2. Identification and habitat of prairie plants. Field work.
3. Identification and habitat of wood plants. Field work.
4. Identification and habitat of wood plants. Field work.
5. Identification of trees. Field work.

"An elementary course to be effective must do three things: *First*, it must give the student an idea of the vital activities of plants to such an extent that they can make practical use of the knowledge in agricultural work and in everyday life. *Second*, it must lay before the student the possibilities of advanced study. *Third*, it must lay a foundation upon which advanced study can be based. For these reasons the course must contain some of each of the following: physiology, ecology, pathology (the more practical lines of study) together with enough taxonomy, phylogeny and histology to make the other lines intelligible."

(To be Continued.)

Digitized by Google

ARIZONA.

By Jehiel S. Davis,
Prescott, Arizona.

To the minds of many, even in the mountain states, the name Arizona brings many false impressions. It is often regarded as a section of heat and desert waste, a strange borderland in a blazing sun, a mañana country sleeping between the east and west.

The meaning of the name of the state is in doubt, being given by different authorities as "Little Creeks," "Blessed Sun," and "God Enriches." The state flower is the white waxy blossom of the Saguaro, or giant cactus. This cactus is very characteristic of the state and sometimes grows to a height of forty or even fifty feet.[1] The state flag is the flag of the copper star.[2]

Arizona is a great irregular rectangle in the southwest, lying partly in the lowlands along the Colorado River and towards the Gulf of California, and partly on the bleak Colorado Plateau. Its latitude is about the same as that of Tennessee and Georgia, Morocco, or Tibet. The northeast corner of the state touches Colorado at the only place where four states meet in one point, and from southern Utah and Nevada it extends south to Mexico entirely between the two great ranges of the cordillera, the Coast Range in California and the Sangre de Cristo and Sacramento Ranges in New Mexico. Arizona touches only the Mexican state of Sonora to the south, where there has been little border trouble. This is because most of the international line is in the almost uninhabited Sonora Desert, and much of this is but a narrow strip of land sixty or seventy miles wide between the United States and the Gulf of California.

The westernmost important towns in Mexico are south of the eastern third of Arizona. The state has an area of 113,810 square miles practically all draining into the Colorado River. A few desert valleys in the south such as the Rio Sonoyta and Rio Asunción or Altar River go directly to the Gulf of California. Roughly the southern quarter of Arizona or a little less, makes up the bulk of the Gadsden Purchase acquired from Mexico in 1852, four years later than the rest of the territory. Arizona was made a territory in 1863, when the trading post of Navajo was the capitol. The capitol was later removed to Prescott, then to Phoenix. Arizona became a state in 1910.

[1] Nat'l. Geog. Mag. Vol. 31, 1917, p. 513.
[2] Nat'l. Geog. Mag. Vol. 32, p. 334.

Digitized by Google

Arizona is mountainous over most of its extent and there are probably no sections in the world more marvelously rough than parts of the state.[3] Some sections are flat however, and there are large divisions differing widely in type. The state may be divided in three great sections, on the basis of climate as well as surface.

The great rectangle of the state is belted diagonally across with rugged mountains from the northwest, towards Nevada to the southeast where the El Paso and Southwestern Railroad winds through the San Bernardino Valley to Douglas in the country described by Zane Gray in *The Light of Western Stars*. Northwest of the mountain belt, the Colorado Plateau rises away into Utah, Colorado, and New Mexico averaging from 4,000 to 8,000 feet in elevation. On it are scattered mountain ranges, many of which are volcanic in origin as are the graceful cones of the San Francisco Peaks which rise to 12,611 feet elevation, the highest point in the state. Some of these evidences of volcanic action are old and worn by ages of weather but others look as though they had been active yesterday. However, the most marked characteristic of the surface of the plateau is the canyon formation which dissects the comparatively flat surface in all directions. This formation culminates in the master gorge, the Grand Canyon.

The great diagonal mountain belt to the southwest of the plateau ranges in elevation from 2,000 to 12,000 feet and really marks the breaking down of the plateau. Peaks rise above the plateau land, but much of the surface, although mountainous, is lower than the flatter surface of the plateau. Some of the rivers flow from the plateau clear through the mountain belt and where the latter forms important divides these run along the edge of the plateau.

South of the mountain belt and to the west, along the Colorado River, are the broad desert lowlands cut by fantastic shaped mountain ranges in a way somewhat opposite to that in which the plateau is canyon cut.

Flagstaff is typical of the cold northeast plateau division. It stands at an elevation of 6,907 feet. Because of the elevation and the fact that there are broad openings of lower elevation all the way to the Pacific Ocean the climate is rather cold and moist, quite different from what many picture for Arizona. The average annual rainfall is 23.87 inches or enough to grow

[3] Nat'l. Geog. Mag. Vol. 32, p. 490.

Digitized by Google

most crops without irrigation if it were not too cold. The average annual snowfall is 83 inches and the relative humidity 62%. The highest and lowest temperatures observed are 93° above and 21° below zero. The average date of the last killing frost is June 7, and that of the first September 20. The climate is sufficiently cold, so that snowshoes are not a curiosity and moving picture companies find excellent Alaskan scenery.

Globe, elevation 3,525, and Prescott, elevation 5,346 feet, are both in the mountain belt. At Globe the average annual rainfall is 16.22 inches while it is 17.4 inches at Prescott. Both of these are higher than the rainfall at San Diego, California, directly on the coast. The snowfall averages 7 and 30 inches respectively. The average relative humidities are about 45% and 55% and the lower the elevation the more continuous the sunshine. The highest and lowest temperatures are 110° and 11° above zero at Globe and 104° above and 12° below zero at Prescott. The average latest and earliest frosts are March 23 and November 17 at Globe and May 21 and September 29 at Prescott.

Typical of the lower desert sections are Phoenix, elevation 1,108 feet, the capitol and largest city of Arizona, and Yuma, elevation 141 feet only, 90 miles from the Gulf of California on the Colorado River. Phoenix has an average annual rainfall of 7.39 inches and Yuma 3.26 inches. There is no snowfall in either place. The humidities average 40.5% at Phoenix and 46% at Yuma. Because Yuma is so near the ocean, its average humidity is an exception to the rule that the lower the elevation the lower the humidity, but there are times when the movement of the air is towards the water that the humidity becomes remarkably low, sometimes below 5%. An impression has grown up since the opening of the irrigation project around Phoenix and Yuma, especially the former, that the humidity has been much increased by the cultivation, but this is shown to be untrue as the measurements of the weather bureau fail to show any appreciable difference in the average. The reason is of course, that the irrigated patches of 200,000 acres or less, are but dots of green in the hundreds of thousands of square miles of desert extending far into Mexico.

The highest and lowest temperatures are 117° and 16° above at Phoenix and 120° and 22° at Yuma. Many are afraid of the summer temperatures in this section, but this fear is groundless. The temperature at the surface of the body is determined largely

Digitized by Google

by the rate of evaporation of the perspiration and in this dry section this is very high, so that the sensible temperatures are very much like those in the central part of the United States or less. This is proven by the fact that heat prostrations common in the sections east of the Rockies are almost unknown in the southwest. To most people who come to southern Arizona during the cool parts of the year and remain through the hot weather this is no more uncomfortable than summer weather in the east and it is a great asset to the farmers. The clear weather with continued sunshine is delightful, and it is at Yuma where the sign over the depot restaurant reads, "Free meals every day the sun does not shine." The average latest and earliest killing frost dates in Phoenix are December 6 and February 16, but around the city there are sections where the air drainage prevents most of the frosts, and citrus fruit culture prospers. There is no record of a killing frost at Yuma.

The leading industry in Arizona is mining, and the state leads all others with a rank as follows in 1916: Arizona $203,000,000, Montana $145,000,000, and Utah $97,000,000. The most important product is copper, which comes from various parts. The largest producers are in the mountain belt as the Globe-Miami, Bisbee-Douglas, Clifton-Morenci, and Jerome-Clarkdale sections. Gold, silver, and lead are important and the total of all the mineral products would make a long list. There are beyond doubt very rich coal and iron deposits in the northern part of the state. These are not yet mined, being in sections not yet carefully explored either because of the large Indian Reservations or the isolating effect of the Grand Canyon. The Indian Reservations were largely opened to prospecting within the last few months.

In the cold plateau there is much pine forest, largely under the United States Forest Service, and lumbering and grazing are the chief industries. Through the great expanses of unsettled mountains and canyons roam many wild animals among which are deer, lion, coyote, bear, fox, small rodents and others.[4] The open expanses of the plateau are well described by Zane Gray in *Riders of the Purple Sage* and *The Rainbow Trail*. There are a few agricultural communities based on dry farming and irrigation, in the lower parts, especially along the Little Colorado River. All these things are sufficient to support only a scattered population, and a few small towns the largest of which is Flag-

[4]Nat'l. Geog. Mag. Vol. 30, pp. 409, 411, 413, 419, 423, 440, 442, 447, 450-1, 454, 458, 463 and Vol. 33, pp. 404, 405, 429, 436, 437, 440, 441, 456, 465.

Digitized by Google

staff, with about 3,000 people. Flagstaff is located in the Coconino National Forest and is a pine lumbering and stock raising center. Because of the cool summer climate and remarkable scenery it is an important summer resort. At Flagstaff are located the Lowell Observatory famous for studies of the planet Mars, and the Northern Arizona Normal School. There are large lime kilns at Nelson. Seligman is a small but rather important cattle center, Winslow is a farming and cattle town having also the railroad division point, and Holbrook and St. Johns are farming and cattle towns.

Farming is also of little development in the mountain belt, although in a few places as in the Gila Valley, irrigation supports good sized communities with such centers as Solomonville, San Carlos, and Thatcher. In the Globe district where flat land is very scarce, there has been hardly a start made, and farther northwest near Prescott where the elevation makes it colder, but a very small part of the land is farmed. However, rapid development is under way in the lower valleys and results are wonderful. Many of the products, especially peaches, apples, and alfalfa are not excelled anywhere, in quality. The pine forests cover the higher parts of the mountain belt even as far south as the Mexican border, but there is very little lumbering. Stock raising is important and is pictured by Harold Bell Wright in *When a Man's a Man.* The great copper centers of the mountains have been mentioned. Most of these are located much as is Globe, in a rugged canyon like valley, and possess a romantic beauty and interest in spite of a certain crudity and the still lingering air of misery and woe, held perhaps, by the plate glass fronts of saloons, gambling houses, and dingy rows of redlight cells which still remain to testify of the wild wide open days of not so many years ago. Prescott is the same, although not as large as Globe, and at some distance from the mining developments for which it is the distributing center. Prescott is a county seat and the largest town in the northern two-thirds of the state. The chief industry of the town is the Santa Fe Railroad shop. It is also a grazing center. Kingman is a combined stock and mining center. Asbestos is mined in the White Mountains near Roosevelt Dam. A number of the copper centers are larger than any other towns in the mountain or plateau sections. Bisbee is a city of 25,000 and Lowell, Douglas, Globe, Miami, Clifton, and Morenci, range from 4,000 to 10,000 although exact figures cannot be given until returns from this 1920 census come in.

Digitized by Google

Mining is also important in the desert, and the type of production is like that already mentioned. There are many centers such as Nogales, Ajo, Polaris, Wickenburg, Swansea, and Hraqua Hala, none of which compare with the mining centers of the mountain belt. The important thing in this land of summer, desert, and beautiful fantastic mountains, is irrigation farming, and this is what supports the largest centers in the state

The Salt River Valley is the largest farming section, and Phoenix in the midst of it, the capitol and largest city of Arizona, has 32,000 people. It is pronounced by many, the fairest city in the intermountain region, from the standpoint of climate, beauty, comforts, and surroundings. It is chiefly a distributing center and the leading industry is the garage and machine shop based on the farm machinery, tractor, and automobile industries in many small units. Dairying, cotton ginning, and flour milling are other important industries. The most of the irrigation is under one of the largest United States Reclamation Projects.[5] It cost over $10,000,000, and irrigates 189,000 acres of land, raising almost anything that grows and cotton, alfalfa and dairy products in largest quantities. It is expected that the acreage will be increased to 219,000.

The water storage is accomplished by Roosevelt Dam about eighty miles eastward, and north from Phoenix on the road to Globe. This great dam, half again higher than Niagara Falls, stores the flood waters from a great area in the mountain belt and regulates their flow so that they will be available for irrigating the desert below. The project supports several other large towns. Tempe and Mesa each have about 10,000 people. Tempe is the seat of the Southern Arizona Normal School and has one of the condenseries of the Pacific Creamery Co. (Armour & Co.) as well as a cotton gin. The other Pacific Creamery is at Glendale. Mesa is an important Mormon town. All around the project, private pump irrigation development is going on. A project to dam the Hassayampa River and irrigate a large tract of land near Hot Springs Junction is reported under way.

The second city in Arizona is Tucson, where is located the State University. The population of Tucson is about 25,000 and the city is surrounded by irrigated farms of the finest quality. The elevation is about 2,000 feet, making the climate very good. Many small projects are springing up where water has been found, and while this will always be a region where there is

[5]Journal of Geog. Vol. 11, May, 1913, pp. 277-284.

Digitized by Google

elbow room, it will be dotted by many large garden spots of green, many more than now appear.

Yuma is surrounded by another United States Reclamation Project. The water is taken from the Colorado River at the Laguna Dam. Yuma has the advantage of more continuous sunshine and heat, and of being almost free of frost. This has made possible such production as 7.5 tons of alfalfa on 7.1 acres. Yuma is one of the gateways to Arizona. There are but three places where the Colorado River is bridged, Yuma, Parker, and Topock near Needles, California. Here the two Santa Fe Lines and the Southern Pacific cross, connecting Arizona with the coast and paralleled by automobile roads, two of which are transcontinental highways. Transportation is so difficult in Arizona, that its development has been much retarded and it in turn has held up other kinds of development. The canyons in the plateau, offer great engineering difficulties, and many parts of the mountains are so rough that it is hard to put a road or railroad through at any cost, while on the desert there is not enough water easily obtainable to operate the railroads in many places, causing great expense to run through empty country. Great distances and thin population also make it impossible to improve the automobile roads as they should be. There are many types of road in Arizona, but the most marked types correspond to the divisions of the state, desert, mountain and plateau. The desert roads are sometimes good, as the grade is near level and the usual adobe soil makes a hard road until wet, when it becomes terrible, and often dries rough and remains so for days. Many of the plateau roads are on volcanic or other clay, and are good when dry and hard but are much more often mired and they run over grades that make these difficulties much greater than on the level roads. In the mountains there are many places where grade and surface make roads practically impossible, except at great expense and with fine engineering skill, so the main roads in many of these places have been built most excellently, and are fine smooth roads. Some have been allowed to wash on the surface until the uncovered rough bare rocks make them nearly impassable. It will be seen that most of the difficulty with roads can be overcome by paving over flat country or grades already built; it is to be hoped that the state extend the few miles of pavement near the larger towns and connect them up. In spite of the size of the state, 1,800 miles of pavement could be made to reach every town of 1,000 population or more, and

Digitized by Google

many points of interest, as well as covering the Arizona parts of the National Old Trails Road, along the Santa Fe, the Apache Trail and the Borderland Trail in the south. Once paved, these roads would be open to easy travel the year round, as even in the highest sections of the National Old Trails road the snow would seldom be found deep enough to stop traffic over a paved road.

To the sight-seer, the railroads are of little value except to get into the state. Almost everything of interest is off the main line of the railroad, off the main road, or off any road, yet it would be hard to find a section of equal size with so many things of great interest crowded into it. Arizona has two National Parks, Grand Canyon, made a park in 1918,[6] and Casa Grande Ruin. Grand Canyon cannot be described. World travelers pronounce its beauty as well as its grandeur, unequalled, and I know by experience that it is so large that one cannot see it from the rim, but must go down the trail into that colored wonderland to even get a suggestion. The canyon is 250 miles long, one mile deep, and averages eight miles wide. Scattered cliff ruins add a romantic human touch to the exploration of these ever changing unpictured tinted crags.

Casa Grande Ruin, made a park in 1889, is the ancient ruin of a community house or town on the desert near Florence. It is thought to be the remains of a people even more ancient than the cliff dwellers who preceded the Indian.

Just beyond the limits of Arizona to the northeast in Colorado is Mesa Verde National Park containing in its 77 square miles of area the most notable, best preserved collection of cliff ruins in this country and also a great many pueblos.[7]

Arizona has seven National Monuments, of which the Petrified Forest is probably the most interesting. As it is the best known collection of agatized trees and should be a park. It is near Holbrook on the National Old Trails Road. Walnut Canyon, Montezuma, and Tonto are all monuments to preserve cliff ruins. The first is near Flagstaff, the second between there and Prescott and the last near Roosevelt Dam. Pueblos and works of the Indians are found in the Navajo National Monument far in the north, while just across the line from it into Utah, is found Rainbow National Monument, containing the largest known natural bridge, 308 feet high, called Nonnezoshe, by the Indians.[8] Just

[6] Bul. of the Pan-American Union, Vol. 13, Oct. 1916.
[7] Bul. of the Pan-American Union, Vol. 44, April, 1917.
[8] Nat'l. Geog. Mag., Vol. 29, p. 376.

Digitized by Google

north of Tempe, red rocks rise from the plain, creating a spot of wild beauty in the very midst of the irrigation project. Here is Hole-in-the-rock, a small natural bridge, where the Apaches used to ambush prospectors. Over this area grow fine specimens of the saguaro cactus. To the east is a Papago Indian reservation and the whole makes up the Papago-Saguaro National Monument. Far to the south is Tumacacori,[9] set aside because it includes the ruins of a mission and relics of the work of monks with the Indians.

Outside the national reservations are many other wonders, as the Apache Trail from Globe to Phoenix,[10] the Roosevelt Dam on this road,[11] Mission San Xavier del Bac[12] near Tucson, New Cave near Flagstaff, Cathedral Cave north of Prescott, Inscription Rocks near the Williams River, and other scattered inscriptions, Indian ruins, cliff dwellings, mountain scenery and the like.[13]

Empty as it may look from the train, Arizona has an overabundance of world wonders, and better still, mineral and agricultural wealth. Here is every type of climate but the damp tropical, and even now a moving picture company is in Prescott taking pictures of the Canadian Mounted Police in the far northwest, while by a half day automobile trip they could be filming the Sahara, the orange groves, Alaskan snow games, or the Hopi Snake Dance.[14]

[9]Sunset Mag., Vol. 43, p. 24, Nov. 1919.
[10]Nat'l. Geog. Mag., Vol. 32, p. 490, Fish Creek Hill.
[11]Journal of Geog., Vol. 11, 1913, p. 281.
[12]Arizona Mag., Vol. 10, 1919. (Aug.) Sunset Mag. Vol. 43, p. 22, Nov. 1919.
[13]Nat'l Geog. Mag., Vol. 29, p. 375.
[14]Nat'l. Geog. Mag., Vol. 29, pp. 385, 392, 397, 398.

OFFICIAL TELLS ADVERTISING MEN NEED OF METRIC UNITS—METER-LITER-GRAM.

In a recent address before members of the Advertising Club of Baltimore, Md., H. D. Hubbard of Washington, D. C., Secretary to the U. S. Government Bureau of Standards made an earnest plea for the adoption of metric units of measurement in the United States.

Mr. Hubbard pointed out that, during the war, American manufacturers were forced to use the metric system in the manufacture of guns and other ordnance, and two principal American locomotive works had to use it in the building of locomotives. If the work on the blue prints for these locomotives had to be done in feet and inches, Mr. Hubbard said, the locomotives would never have been built. He further said that America by refusing to adopt the metric units is keeping herself as far behind in the matter of proper standards as was China, who has now adopted metric units.

Digitized by Google

STANDARDIZED TESTS IN SCIENCE.

By Ralph E. Wager,
Normal School, De Kalb, Ill.

(*Continued from December, 1919.*)

Passing now to the third point, that of method, let me state at the outset that I have no idea of attacking the general plan of current procedure of making use of both laboratory and textbook. A passing allusion to the too great attachment to the textbook on the part of many teachers, together with the neglect of the laboratory phase of the work, is sufficient to call up one of the most serious errors. It is not merely information we should strive to put over, but rather an attitude of mind, or a way of thinking, recognizing meanwhile of course, that some knowledges are worth while in many ways. But the too constant and insistent effort merely to obtain a recitation in terms of the textbook develops only an attention to the matter of memorizing enough to satisfy the requirements of the teacher whether or not a significance obtains.

I have already alluded to the project as a scheme for making use of the larger life-environment of the child as the laboratory. This offers boundless possibilities. It seems then that we should develop projects in conformity with this idea and try them out. Probably a helpful undertaking would be to list all such and submit them to earnest teachers for trial and criticism. Inasmuch as reference has been made to the desirability of standardizing such projects we may leave this point without further discussion. To pass then to another related phase, I would like to call attention to the fact that there is need for experimental teaching, and considerable investigation into the most economical and efficient methods of procedure; such as, for example, that of Gilbert, in which he compared the results in teaching zoology when emphasis was placed on the economic approach and that of pure science. Or such as Webb's study in the comparative results in teaching chemistry by laboratory, lecture and combination methods. We need thorough surveys of the content and capacities of pupils at the time they enter our classes. Grier's report on the results of his range of information test in physiology is most suggestive in that he discovered that much of the current terminology, and presumably, therefore, no little of the meanings, of hygiene, is obtained outside the classes dealing with that subject. Newspapers and magazines have

Digitized by Google

done much to educate the layman. We should know where to begin without loss of time and effort.

All of this type of investigation demands, however, the formulation of standardized tests. Before we can do that we must have a certain starting point in both content and purpose. With such instruments results by different methods become measurable and comparable. Without them they remain as now, mere matters of opinion.

Still another point remains to be made in this general connection. The realization of the great differences in the capacities of pupils is leading to well developed means of making a division of our school population into at least three large classes: the dull, the medial, and the bright pupils. I am assuming that no genuine subnormals find their way into the high school! In English and history as well as mathematics, this division is finding favor. It remains for us then, to develop means for separating pupils into similar groups according to their capacities to do the work in science. Thereafter it is essential that the work be made to fit the group. Herein is, I think, one of the most important and essential steps we can take, and its importance cannot be overemphasized. As scientists we should not bring up the rear when the application of scientific methods is involved.

Mention has been made of the standard test as an important and essential tool. Undoubtedly many of you are familiar with the beginnings already made to develop it, although none with which I am familiar have been well standardized. Some of these are: Grier's Range of Information Test in Zoology and Physiology, Downing's Range of Information Test in Science, Bell's First Year Chemistry Test, Caldwell's Garey Survey Tests, Herring's Test of Abilities in Scientific Thinking. As I have stated, these tests have not been standardized. For such a process, a group of schools cooperating, let us say for two years, ought to yield a test of sufficient reliability to make it worth while.

We come now to a point from which I wish to digress a bit from the general implications of my topic, but I feel that your interest in the undertaking I have in mind to suggest will carry us along in a spirit of cooperation.

If you will put your ear close to the ground, you will hear rumblings of dissatisfaction with our present content in history. Already ancient history has been relegated as a requirement by some of the leading universities, and thoughtful laymen are

Digitized by Google

asking as to why so great emphasis is being placed in our present history courses upon the political and military aspects. Labor unions are demanding that history be taught from the viewpoint of the development of industry. There has been appointed, I understand, a committee of noted historians to make certain revisions in the history outline. Now, why not, let us ask, teach the origin and growth of the great ideas in science as a part of, yes, indeed, as the basis for, an understanding of industrial developments? Quite generally the mission of science and scientists is entirely misunderstood; and for good reason. Did people generally know something of the nature and significance of the contributions science has made to the happiness and welfare of man, and of the infinite patience and unflagging labors involved in their discovery, much good would come through a more wholesome respect for them. Yet ignorance is all too patent with reference to both the principles and the men who discovered and formulated them. As an illustration let me present the following bit of evidence: A few days ago I tried out a class to determine if some of the common names in science were familiar or unfamiliar, and if the former, to what nationality its possessor belonged. This test is about as simple as one could be made. There were thirty-one pupils, all high school graduates. The results:

Name of Scientist	Heard of or read the name	Unfamiliar	Nationality known	Nationality unknown
Tyndal	9	22	4	27
Pasteur	13	18	4	27
Lyster	0	31	0	31
Koch	2	29	0	31
Huxley	15	16	6	25
Darwin	30	1	19	12
Lamarck	0	31	0	31
Priestley	3	28	0	31
Copernicus	3	28	0	31
Galileo	16	15	0	31
Bessemer	1	30	0	31

Choosing the name most familiar I then asked for some definite association with it. The results are most suggestive. With the name of Darwin these associations were reported:

No. of Pupils
- 20—The originator of the theory of evolution.
- 1—Something to do with religion.
- 2—A great atheist.
- 1—A botanist of great renown.
- 1—A great scientist.
- 1—A scientist and atheist.
- 1—The originator of the idea of sexual selection.
- 4—The originator of the ideas concerning the origin of species.

Digitized by Google

It seems hardly possible that these young people have come up through our high schools with these notions, and yet it is not surprising when you contemplate the manner in which history has been presented. Would it not lend somewhat, I would like to ask, to the feeling of brotherhood between nations, and to realization of the mission of science, were pupils in our schools to discover that to science all civilized nations have made contributions, and that to all nations it has ministered in so far as they have been able to adopt and make use of it? I would then, suggest a course in the fourth year of the high school, or before if possible, dealing with the development of science in the world, and with some of the large ideas which have contributed so bountifully to the cause of civilization. Such a course would serve to tie the science together into a unified whole, furnish at the same time an opportunity for a review of the salient points in each science element, and at the same time present a true picture of man's progress toward his present control over Nature. By whom such a course were taught were immaterial in so long as he permits the pupil to discover the truth and think for himself. If we are about to enter upon an age dominated more and more by scientific thought and method, certainly the high school should strive to give at the least an understanding of the history and mission of science. The *odium religicum* is so far decadent, let us hope, as to make such a course possible. There is opportunity also for brief and simple biographical sketches of the lives of scientists for use in the upper grades.

I come thus, by a somewhat circuitous route, to the statement of a plan for the development of standardized tests. You will suspect me of trickery for I have managed to bring into my discussion some apparently unrelated materials. When, however, you think the problem through, you will understand that before useful tests can be made all these other facts must be passed in review, evaluated, and procedure directed accordingly.

A summary of the points I have tried to make may now be made. They involve:

I. A survey of the outcomes of the present courses of study as they are presented in a series of typical schools. We must satisfy ourselves as to what we are now accomplishing.

II. The establishment of definite aims after (a) reviewing the present outcomes, (b) examining the courses in the curriculum to which our subjects may contribute, (c) attempting to discover vital relations with actual life activities.

III. The development of standardized tests based upon the aims thus set up.

Digitized by Google

IV. The initiation of experimental teaching (a) to determine the most efficient methods, (b) to discover the most difficult and most commonly misapprehended points in the subject matter from the pupils reaction to them.

V. To list, standardize and develop projects and problems.

VI. To devise means for grouping pupils according to abilities in science work, and to adapt materials to such abilities.

Somewhat apart from this logical sequence in the larger plan is that concerning the introduction of the history of the great scientific ideas and their relation to man's progress. This involves investigation and agitation as well as the organization of such a course as to content.

Finally, if we are to bring our science work into accord with modern educational demands, and if we are to keep pace with the progress now being made in other subjects, we must follow some such plan as I have tried to present. I therefore submit it for your consideration and frank criticism.

TEACHING BOOKKEEPING BY THE HISTORICAL METHOD.[1]

By A. P. R. Drucker.

Those who have had experience in teaching bookkeeping know only too well the difficulties they have encountered in their attempt to explain to students the reasons for the rules of bookkeeping. Indeed, very few teachers ever try to assign reasons for these rules; they simply insist that the students master the rules and then work out the exercises illustrating their application. In other words, they teach the hows but not the whys of bookkeeping science. The result of this insistence upon the memorizing of unexplained and uncomprehended rules is naturally more or less confusing in the minds of the learners. The vagueness of the subject finally discourages the students, who are for the most part groping in the dark, never sure of their ground, their weak grasp of the subject becoming fatal to their enthusiasm.

The answer of a certain student to the question—what would he do in case he received a telegram from the freight agent notifying him that the consignment of goods he had expressed to John Brown had been destroyed en route: that he would debit the telegram in accordance with the rule to "Debit whatever is received"—ludicrous as it may sound, is nevertheless typical of the bewilderment resulting from the usual vague presentation of the subject and of the uncertainty the student feels in trying

[1]Address made before the Commercial Section of the Oregon Teachers Association.

Digitized by Google

to apply the rules of bookkeeping to business transactions. As a matter of fact, very few even among practical bookkeepers have more than a hazy idea about the application of the rules of the subject.

By defining bookkeeping as an art, the old textbooks themselves admitted that the rules of the subject are those of an art—intuitive only, and therefore not referable to reason or demonstration. In this way they evaded the necessity of assigning reasons for the rules of debit and credit.

This method of teaching bookkeeping, however, is not only futile, but it is also far from a true appreciation of the rules of the subject. For these rules are no more inexplicable or obscure than are the rules of arithmetic or algebra. Bookkeeping rules, like those of mathematics, are based on logic pure and simple. For indeed the obscurities ordinarily attributed to them are more apparent than real, more due to a lack of historical perspective than to the fact that the underlying reasons cannot really be found.

The obscurity surrounding the rules of bookkeeping is largely due to the peculiarly uneven historical development of the subject during the centuries of its growth. If we study the history of bookkeeping carefully, we shall find that while the systems, forms, and methods of bookkeeping progressed steadily, in accordance with the demands of business needs, the rules were not changed to fit the new conditions. Instead, they were simply extended—stretched out, as it were—to embrace the newest methods and devices. Under these circumstances it was only natural that the rules when taken out of their historical setting and applied to new systems and practices, should lose their original axiomatic reason and appear obscure and incomprehensible. By looking at these rules from a historical standpoint, however, we can readily detect not only the basic reasons but also the logical and reasonable method of development.

An illustration will make this point clear. If a student should ask the instructor the reason for the rule to "Debit cash when it is received into the business," the instructor would be at a loss for a clear explanation. If he himself has never studied the subject from the historical standpoint he will be quite unable to assign any reason for this rule. Some authorities, in their endeavor to give some kind of explanation for the rules of debit and credit, have resorted to rather fanciful reasons. They have adopted what is known as the "personification idea"; that is, they have

Digitized by Google

personified the impersonal accounts. We debit personal accounts, they say, when the persons receive something of value from the business. In the same way we may personify cash and thus debit it when "cash" receives money, because we look upon cash in the light of a person. Such a fantastic and rather farfetched explanation goes to show the straits to which the teacher is driven in trying to find some kind of reason for an apparently obscure rule.

Again, Professor W. M. Cole of Harvard has modified this personification idea somewhat by a rather ingenious turn. He tells us that *debit* means assuming responsibility, and *credit* releasing responsibility. In personal accounts, Professor Cole reasons, we debit a person who buys goods of us because he becomes responsible to the business for the debit, and we credit him when he pays the debt because by paying he is released from his responsibility. By applying the same idea to impersonal accounts, Professor Cole assumes that when cash is received into the business, *cash* becomes responsible for the amount thus received and hence is debited for the amount. On the other hand when money is paid out of the business cash is credited for this amount because "cash" is released from its responsibility for the amount in question.

While this explanation is most ingenious and in many instances most helpful, it is nothing more than a fine modification of the old personification idea. We hold "cash," an impersonal object, responsible for money it receives by personifying cash. Besides this attempted explanation does not account for all the applications of the rules of debit and credit. It cannot for instance explain these rules as applied to profit and loss. Why should we credit profit? Where is the responsibility released?

But above all, neither the personification idea nor its modification, the "responsibility idea," are true to the historical development of bookkeeping. Neither of these ideas were in the mind of the bookkeeper who first extended the rules of debit and credit, to impersonal accounts. In order to arrive at a true insight into the mental attitude of the originator of the application of the old rules for debit and credit to cash in double entry bookkeeping let us for a moment trace the historical development of bookkeeping and note the actual reasons for the application of the rules of debit and credit to impersonal accounts, as they occurred to the inventor of the system.

The first attempt at scientific bookkeeping was the single-

Digitized by Google

entry method. At first only the daybook was used. In this book only personal accounts were recorded, and in this connection of course the terms *debit* and *credit* had a clear meaning. The word debit comes from the Latin verb "debere," to owe; credit is derived from the Latin verb "credere," to trust. Hence, these terms when applied to personal accounts had a perfectly lucid meaning. The term debit, meaning "he owes," was applied to a person who purchased goods of the business on account; while the word credit, which means "he trusts," was applied to a person who sold goods to our firm on account and trusted us for the amount. Therefore, the rules for debit and credit were as follows:

"Debit a person for what he receives from the business on account (i. e., for what he owes); and

"Credit a person for what he gives to the business on account (i. e., for what he trusts)."

At this stage of its development, bookkeeping called for such books of record as helps to the memory only; hence, where there was no need to remember an item of business, there was also no need to keep a record of the transaction involved. Accordingly, when a customer paid his debt to us or when we paid our creditor, the transaction was completed and the account was crossed off the books. Hence, there was no other record made of the payment.

The growth of commerce, however, made this simple kind of bookkeeping impracticable. Customers sometimes paid only a part of their debt and thus placed the bookkeeper in a dilemma as to how to keep a clear record of their account. Or again, we bought merchandise of a certain firm several times in the course of a short period. Under these conditions it became easy to make mistakes, such as crossing off the wrong transaction. Besides, it took a long time for the bookkeeper to locate the various items relating to the one customer in the many pages of the "daybook" in order to know whether this customer bought four or five times in the course of a month. For these reasons the helpful ledger with its assembled accounts under the names of the various persons doing business, made its appearance.

The ledger carried with it a new and revolutionary principle, namely, the principle of "counterbalancing" accounts. The whole principle of the ledger is derived from the action of a pair of scales or perhaps a lever and a fulcrum. When the bookkeeper observed how one scale with a weight could be counterbalanced

Digitized by Google

by placing an equal weight on the other scale, he thought that the same principle could be applied to his ledger. If one side of the account is weighted down because of merchandise sold, then when payment is made, this cash amount when placed on the other side of the ledger should counterbalance the original account. Therefore, not only did the bookkeeper of this period adopt the system of vertical and horizontal crossbars in his ledger—a device resembling the ancient form of a pair of scales, but he also adopted the principle of a pair of scales in his bookkeeping by virtue of which, instead of subtracting one amount from the other when payment was made, he simply placed the subtrahend on the side opposite that containing the original item, and thus he counterbalanced the original account and made the two sides balance.

Under the ledger system, therefore, when an account was paid, instead of cancelling the old items or subtracting the money payment from the value of the merchandise item as was the old method and is still done in the arithmetical process, the bookkeeper placed the payment of the cash on the side of the ledger opposite that showing the original indebtedness, and the account was thus equalized or counterbalanced. The original rules of debit and credit were not changed, however; instead, their meaning was extended to include the new method. Thus the rules still read the same as before; "Debit a person for what he received from the business; and credit a person for what he gave to the business." Now, however, the meaning of the word *debit* was not limited to the case of the person buying the goods of us on account and thus really owing us money; but it was applied also to a person who received money of us for a debt we originally owed him. We now "debit" this person even though he does not owe us anything. This debit is nothing more than a counterbalancing or rather offsetting of the item on the other side of the account, the original item. And since the former happened to be a credit, we call its offsetting or counterbalancing item, a debit. The same idea holds true of the term *credit*. This term also is not limited now to the person who gives or entrusts merchandise to us on account, but it is also applied to the person who has paid us an old debt for which we had originally debited him. Being thus credited does not mean that this person trusts us for anything; it is used merely as an offset or counterbalance to the original debit item, and is therefore called a credit notwithstanding the original meaning of the term *credit* does not apply here.

Digitized by Google

This extension of the original meanings of the terms debit and credit was legitimate, because it followed in every instance the rule originally laid down for debiting and crediting. We debited personal account when the person received something (this time cash) from the business. Likewise we credited the personal account when the person gave something (in this instance cash) to the business.

It was the idea of balancing and counterbalancing accounts in the ledger that suggested the principles of Double Entry to the bookkeeper. It was apparent to every bookkeeper that a business transaction has a counterbalancing effect on the business; that is, the two factors that enter into the transaction counterbalance each other. In every transaction there are two factors, usually one personal and the other impersonal. If our business buys merchandise from John Smith on account, the two factors, Smith and merchandise, influence our business in such a way that their forces counterbalance each other—and so our business is left in the same condition as it was before the transaction. Suppose our business bought goods for $1,000 on account from John Smith. In accordance with the rules of single entry, we would credit Smith for $1,000 on our books. As the item is posted in the ledger it would show a liability on our business; it would show that we owe John Smith $1,000; hence, our business apparently is poorer by this amount. But is the business really poorer? By no means, for as an offset to this recorded liability to Smith, the business has received an impersonal item, merchandise, worth $1,000, as an added asset. Hence the personal liability incurred by the business in buying of Mr. Smith on account was offset by the addition of impersonal goods to the business.

The same principle holds true when the business sold goods on account. The personal account receivable that has apparently increased the assets of the business is offset by the amount of the goods sold to that person which is taken out of the business. Hence we see that in every business transaction one factor in the transaction offsets the other, so that the two counterbalance each other. Since accounts with these two factors would supplement each other, the idea suggested itself to the bookkeeper, why not keep a record with both, so that the books may always be in balance. The principle underlying this novel idea was not very complicated. All that was necessary was to apply this idea to the daybook and give it debit and credit columns and make

Digitized by Google

these two columns counterbalance each other. As the bookkeeper was already familiar with the idea of applying the terms debit and credit to offsetting accounts he could see no reason why the same terms could not be used in double-entry bookkeeping, by extending somewhat the ideas of these terms. For inasmuch as there exists a peculiar relationship in business transactions between the personal account and the impersonal item that was bought or sold, there was no reason why the words debit and credit could not be used including these ideas. In their original sense they could be used when they applied to personal accounts and in their expanded sense as counterbalancing or offsetting accounts when applied to impersonal accounts. Hence if we sold goods to Brown for $1,000 on account, our bookkeeper would debit Brown for that amount—the word debit signifying that Brown owed us $1,000. And as an offset to this personal debit to Brown, he would then credit an impersonal account—in this case merchandise, because it was for merchandise that Brown was debited. When Brown pays the $1,000 we will credit his account, as explained before, as an offset to his original debit for the same amount. But in accordance with the rules of double-entry bookkeeping every credit must have an equal offsetting debit. Therefore, we debit an impersonal account—cash, as an offset or counterbalance, because Brown's personal account was credited for the cash he gave the business.

We can now understand the reason for the rule that cash is debited when received into the business. It is debited because the person who gave it was credited for it. Hence we debit the impersonal item cash that was given to the business in order to offset or counterbalance the personal credit.

From this historical illustration it will appear evident how the change in the methods of business forced the extension of the meaning of some of the terms beyond their original import, and consequently brought about an obscuring of the rules. The same holds true for some of the other so-called "obscure" rules of bookkeeping. The only way in which we can arrive at their underlying reason and explanation is by following their historical growth and noting their changed meaning.

In other words then, bookkeeping should be taught as a science and presented from the scientific standpoint, with reasons and explanations for its rules. In order to be able to explain the reasons underlying the rules, the teacher must follow the historical development of his subject from its early beginnings, showing

Digitized by Google

when, how and why the various improvements and modifications were made and the various rules applied. As the student learns not only the rules but also their reasons there is less and less need of routine memorizing and heavy lessons of practice work. As in the study of every other science, the students are thus given theory and practice in reasonable proportion. They themselves become interested and keenly responsive, and feel all along the way that they have the subject well in hand—a condition quite the reverse of the blind groping which has too long been the prevailing attitude of students of bookkeeping under the usual methods of teaching this subject.

THE RANGE OF INFORMATION TEST IN SCIENCE REVISED.

By Dr. Elliot R. Downing,
The University of Chicago.

In a previous article (School Science and Mathematics, Vol. XIX, pp. 228-233) the present writer reported the returns from a range of information test given to several hundred High School Freshmen, College Freshmen and Sophomores. Since then the test has been given to several hundred additional pupils, including a large number in the Quincy, Illinois, Schools, principally in grades seven to ten. I am indebted to Mr. O. D. Frank for conducting the tests in the Quincy schools. The purpose of the present article is to present the results of these additional tests and to combine them with those before obtained. As was suggested in the preceding article, it seems advisable to cut down the test for High School pupils to fifty words instead of using the full one hundred, since many of the terms are quite unfamiliar to them. This will shorten the test, at the same time rendering it no less efficient. This article will present the revised test and the method of its revision.

The test given consists of one hundred words and phrases selected to suggest important generalizations in science that it might be reasonably anticipated would be meaningful as a result of Nature Study instruction in the grades or General Science in the High School. Roughly, one-third of these are taken from Biology, one-third from Physiography and Geography, and one-third from simple Physics and Chemistry. Each pupil is asked to mark with an "E" such terms on the list as he can define or explain, with an "F" those recognized as familiar but which he cannot now explain, and with an "N" those totally new. He is also asked to define or explain the first three he marks "E."

Digitized by Google

These definitions give a check on his own estimate of his knowledge. If one or more of his explanations are incorrect his "E" score is cut down accordingly, and his "F" score proportionately increased. Thus if a pupil marks twenty-one words "E," thirty "F," and forty-nine "N," and one of his three explanations is incorrect, his corrected score would be "E" fourteen, "F" thirty-seven, "N" forty-nine. Definitions or explanations are accepted as correct if they show the pupil has the right idea even if his explanation is not technically exact. The monotony of looking over these hundreds of papers is relieved by the humor of some of the definitions given. For instance "Adaptation" is often explained as "when you take somebody else's baby and treat it like your own." One ninth grade pupil defined "Photosynthesis" as "a disease from which one very seldom recovers. Generally when they recover it usually leaves them crippled in some way." "Battery pole" is defined as "where a ball player stands in the game to bat the ball." "Comet" is "where something funny gets done or acted."

The results thus far achieved are as follows:

TABLE I.

No. pupils tested.		Av. original score.	Av. cor. score.	Av. no. words scaled down.	% of scaling
238 Quincy, 7th grade	E	10.7	2.3	8.4	78.5
	F	19.	27.4	.....	.....
184 Quincy, 8th grade	E	13.3	4.6	8.7	65.5
	F	20.9	29.6	.....	.....
108 Uni. High, 9th grade	E	26.5	18.	8.5	32.1
	F	21.9	30.4	.....	.....
112 Fenger H. S., 9th grade	E	21.5	17.2*	4.3	20.
	F	17.1	21.4	.....	.....
226 Quincy H. S., 9th grade	E	25.2	17.3	7.9	31.4
	F	24.6	32.5	.....	.....
83 Quincy H. S., 10th grade	E	24.1	14.3	9.8	40.7
	F	28.9	38.7	.....	.....
141 DeKalb Normal School, Freshmen	E	34.6	34.6	.....	.....
	F	30.	30.	.....	.....
73 Normal School, Fresh., St. Louis & Kalamazoo	E	32.	32.	.....	.....
	F	33.9	33.9	.....	.....
83 DeKalb Normal School, Soph.	E	44.7	44.7	.....	.....
	F	32.7	32.7	.....	.....

It is rather remarkable that the three High Schools give results that are so nearly coincident. It is to be noted that the words marked "E" do not coincide as pointed out in the pre-

*An error in the preceding article gave the uncorrected figures instead of the corrected for the Fenger High School.

Digitized by Google

ceding paper. Yet even in this particular there is a much larger per cent of agreement than of difference. This will be seen from the following tabulation, and also from the accompanying graph which reveals the significance of the figures at a glance.

TABLE II.

	Percentage of Pupils Marking Words E.			
	U. High.	Fenger.	Quincy.	Av. 484 H. S. 9th.
1. Action & reaction are equal	13.9	2.7	9.2	8.7
2. Adaptation	30.5	12.5	25.6	25.
3. Alpine flora	8.3	3.6	4.	4.8
4. Angle of reflection	17.6	4.5	4.8	7.6
5. Animal society	21.3	8.	15.4	14.9
6. Atom	47.2	52.6	62.8	53.7
7. Avagadro's law	0.0	0.0	.4	.4
8. Battery pole	10.1	8.	7.4	7.3
9. Buoyancy	50.	17.8	58.4	44.
10. Candle power	38.9	27.7	32.7	33.3
11. Center of gravity	40.7	19.6	14.6	22.5
12. Comet	48.1	41.9	46.4	45.
13. Commensalism	0.0	3.6	1.3	1.4
14. Composition of forces	11.1	2.7	7.9	7.2
15. Conduction	36.1	31.2	47.3	41.7
16. Conservation of energy	44.1	17.8	31.4	31.8
17. Dew point	82.4	67.8	81.8	77.3
18. Differentiation of tissues	7.4	3.6	4.4	4.9
19. Disease organisms	16.6	11.6	19.4	16.9
20. Drowned valley	26.8	40.1	8.8	22.1
21. Eclipse	71.3	60.7	67.7	67.2
22. Egg	71.3	61.5	81.4	74.2
23. Electrical resistance	23.1	8.	17.7	16.3
24. Electro-magnet	28.7	14.3	22.5	22.5
25. Enzyme	1.8	33.	29.2	21.9
26. Erosion	12.9	61.5	55.7	48.7
27. Equinox	37.	57.	25.6	37.6
28. Evolution	28.7	29.4	19.9	25.
29. Family tree	53.7	26.8	30.9	34.3
30. Fertility of soil	71.1	38.4	66.8	65.1
31. Fertilization of egg	25.9	49.	45.5	40.5
32. Flood plain	14.8	49.	17.7	28.7
33. Fossil	29.6	45.5	47.7	41.9
34. Gas diffusion	55.5	5.4	63.2	42.7
35. Germ plasm	4.6	2.7	8.2	5.8
36. Heat expansion	74.1	65.1	74.3	70.1
37. Ionization	1.8	3.6	3.	2.9
38. Isomer	2.8	0.0	6.6	4.1
39. Induced currents	5.5	3.6	13.2	9.3
40. Inertia	4.6	7.1	3.	4.9
41. Inoculation	40.7	8.9	22.9	23.1
42. Instinct	62.9	44.6	59.7	56.
43. Law of definite proportion	10.2	4.5	10.	9.7
44. Law of gravitation	51.8	13.4	31.4	30.6
45. Law of the lever	20.3	4.5	42.	26.4
46. Law of the pulley	21.3	3.6	44.2	26.4
47. Laws of fluid pressure	11.1	4.5	20.3	13.
48. Lines of magnetic force	17.6	7.1	7.	11.5
49. Mature topography	0.0	11.6	.8	3.9
50. Mendel's law of heredity	2.8	17.	1.7	6.
51. Metabolism	0.0	16.3	.8	4.1
52. Metamorphic rock	1.8	2.7	1.2	4.5

Digitized by Google

53. Migration	61.1	58.	67.7	61.8
54. Mimecry	14.8	15.2	11.9	13.6
55. Molecule	65.7	61.5	84.9	72.2
56. Momentum	25.9	18.7	22.9	22.3
57. Moraine	34.2	44.6	14.	7.4
58. Mutation	1.8	1.8	13.2	7.
59. Natural selection	20.3	16.3	16.2	14.3
60. Nebula	3.7	3.6	3.	2.7
61. Neap tide	3.7	2.7	6.	6.4
62. Nitrifying bacteria	8.3	16.9	18.1	17.2
63. Nonconformity of rock strata	4.6	3.6	2.1	3.7
64. Non-inheritance of acquired characters	14.8	15.2	9.2	11.5
65. Normal curve of variation	8.3	1.8	4.4	5.5
66. Orbit of the moon	28.7	30.3	21.2	26.4
67. Osmosis	2.8	33.1	42.	32.6
68. Oxidation	15.7	52.6	28.8	32.5
69. Photosynthesis	75.9	51.7	67.7	62.2
70. Parasitism	18.5	42.8	30.4	26.6
71. Planetessimal hypothesis	1.8	4.5	2.5	2.6
72. Plant or animal cell	30.5	52.6	48.6	55.8
73. Polarized light	7.4	4.5	6.6	6.8
74. Precession of the equinoxes	12.9	13.5	3.9	9.1
75. Precipitate	39.8	45.5	21.6	32.3
76. Pure line	5.5	2.7	11.8	7.8
77. Refraction of light	8.3	2.7	9.6	8.6
78. Regeneration of parts	11.1	22.3	7.8	11.9
79. Relation of frequency to pitch	0.0	3.6	3.	2.5
80. Reversion	15.7	8.9	24.8	17.5
81. Saturation	75.	63.3	73.9	8.6
82. Sedimentation	31.5	18.7	41.2	34.3
83. Solar system	24.1	72.3	26.9	39.6
84. Specialization of function	6.5	6.2	3.	4.5
85. Specific heat	11.1	7.1	20.3	14.4
86. Spectroscopic analysis	1.8	0.0	2.1	1.6
87. Spontaneous generation	3.7	5.4	7.	5.6
88. Stable equilibrium	4.6	8.9	4.8	6.
89. Star	62.9	59.	71.	69.6
90. Sterilization	75.9	41.9	80.6	66.1
91. Sub-atomic energy	1.8	.9	9.2	5.2
92. Surface tension	6.5	.9	4.4	4.5
93. Symbiosis	1.8	3.6	3.9	3.1
94. Synthetic sugar	1.8	2.7	3.	2.9
95. The ice age	31.5	23.2	41.2	34.1
96. Toxin	28.7	19.6	20.3	21.7
97. Tropism	2.8	0.0	2.5	1.8
98. Valence	2.8	1.8	3.	3.1
99. Variation	50.9	31.2	51.7	46.7
100. Vertebrate type	8.3	29.4	5.2	11.5

It is very evident that the test would be inappropriate below seventh grade for in this grade the average number of words correctly scored "E" is only 2.3. The seventh grade may be regarded then as the zero point for the test. Another important item appears from the first tabulation, namely, that students' estimates of their own ability increase in accuracy as they advance in the course. Among college students there is no scaling of their "E" grades, for they define or explain with certainty the terms they think they can explain. They know what they know

Digitized by Google

and are correspondingly cognisant of what they do not know. In the seventh grade, however, they mark "E" many terms they cannot explain satisfactorily, so that the number of words incorrectly defined is 78.5 per cent of those marked "E." This per cent decreases to zero among college Freshmen. There is also a fairly regular increase in the number of words correctly marked "E" from the seventh grade up through the college Sophomores.

There is a constant difference in the ability of boys and girls as revealed by the test; the girls mark fewer words "E" and more "F" than the boys. This is shown in the following tabulation:

TABLE III.

		Before correcting.		After correcting.	
		Boys.	Girls.	Boys.	Girls.
7th grade, Quincy	E	11.8	10.1	2.3	2.1
	F	17.6	20.2	27.	28.
8th grade, Quincy	E	16.	12.	6.3	3.3
	F	19.2	22.1	29.	31.
9th grade, Quincy High	E	27.4	22.5	20.4	15.
	F	24.	26.	30.8	33.7
10th grade, Quincy High	E	26.5	20.3	18.1	10.8
	F	27.6	34.	35.9	43.5
9th grade, U High	E	26.5	26.1	18.	17.5
	F	21.9	22.9	30.4	34.5
9th grade, Fenger High	E	23.6	18.9	20.	14.3
	F	17.5	19.9	21.	24.5
DeKalb Freshmen	E	36.3	34.2	no change	
	F	28.1	30.4	no change	
DeKalb Sophomores	E	51.2	41.6	no change	
	F	24.4	33.8	no change	

Including now thirty-eight (38) papers from High School, ninth grade, received from two other schools, Kalamazoo, Michigan, and Platteville, Wisconsin, there have been scored four hundred eighty-four (484) papers for this grade. The average uncorrected score is E, 24.4, F, 22.8, N, 52.8; corrected score E, 17.6, F, 27.2, N, 52.8.

41 of the words on test are marked "E" by 0— 9.9% of these Freshmen.
13 of the words on test are marked "E" by 10—19.9% of these Freshmen.
14 of the words on test are marked "E" by 20—29.9% of these Freshmen.
11 of the words on test are marked "E" by 30—39.9% of these Freshmen.
8 of the words on test are marked "E" by 40—49.9% of these Freshmen.
3 of the words on test are marked "E" by 50—59.9% of these Freshmen.
6 of the words on test are marked "E" by 60—69.9% of these Freshmen.
4 of the words on test are marked "E" by 70—79.9% of these Freshmen.

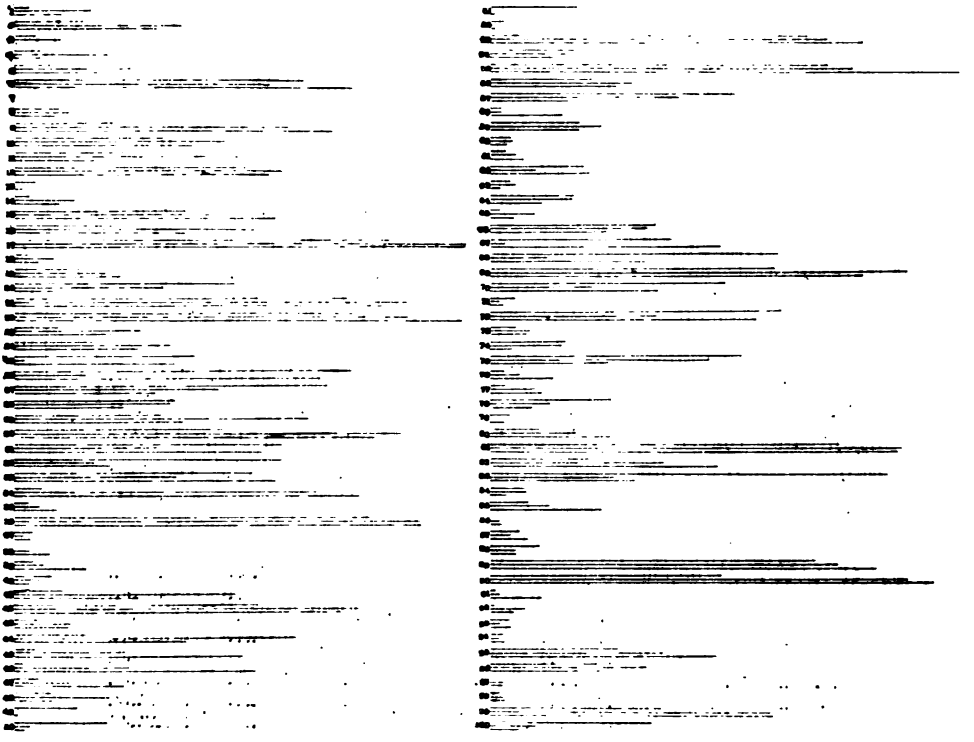
100

The details of this statement appear in the fourth column of totals, in Table II above.

It is very evident then that more than half the words are marked "E" by less than twenty per cent of the pupils. It

Digitized by Google

seems advisable then to omit these words that are largely unknown and so reduce the list to fifty words. All words therefore marked "E" by fourteen per cent or less of the High School Freshmen are omitted from the revised list, and also three words scoring much higher but which are misleading as shown by the definitions. These three are animal society, egg, star. It was hoped the word "star" would suggest the notion that these bodies are distant suns, that "egg" would signify that speck of living substance from which the animal or plant develops after its fertilization, and that "animal society" would have an ecological significance, but most pupils think of a humane society in connection with animal society, food in connection with the



term "egg," and a twinkling object seen in the sky as a "star." The number of terms to be defined is increased to five, to get a better check on the student's estimate of his own ability. The revised test is as follows:*

Digitized by Google

Please put an E beside words and phrases (on the list below) that you can explain or define, an F beside those you have heard or read about, the meaning of which is not clear, and an N beside those that are new. Explain or define the first five you mark with an E, on the back of this sheet.

No.	Mark Here.		No.	Mark Here.	
1		Adaptation	26		Inoculation
2		Atom	27		Instinct
3		Buoyancy	28		Law of gravitation
4		Candle power	29		Law of the lever
5		Center of gravity	30		Law of the pulley
6		Comet	31		Migration
7		Conduction	32		Molecule
8		Conservation of energy	33		Momentum
9		Dew point	34		Natural selection
10		Disease organisms	35		Nitrifying bacteria
11		Drowned valley	36		Orbit of the moon
12		Eclipse	37		Osmosis
13		Electrical resistance	38		Oxidation
14		Electro-magnet	39		Photosynthesis
15		Enzyme	40		Parasitism
16		Erosion	41		Plant or animal cell
17		Equinox	42		Precipitate
18		Evolution	43		Reversion
19		Family tree	44		Sedimentation
20		Fertility of soil	45		Solar system
21		Fertilization of egg	46		Specific heat
22		Flood plain	47		Sterilization
23		Fossil	48		The ice age
24		Gas diffusion	49		Toxin
25		Heat expansion	50		Variation

Recounting the scores made by the four hundred eighty-four High School Freshmen on the fifty words retained in the revised test the average uncorrected score is found to be "E," 37.2, "F," 26.8, "N," 36.*

*Copies of the revised test can be obtained from the author, The University of Chicago, The School of Education, for $0.30 per hundred.

Digitized by Google

QUICKSILVER IN 1918.

Although quicksilver is not a precious metal and, unlike iron and copper, is not one of the great basic materials of industry, nevertheless its unique position as the only metal that is liquid at ordinary temperatures and its varied and special applications in science and the arts give it peculiar interest. The report of the United States Geological Survey, Department of the Interior, on quicksilver in 1918, prepared by F. L. Ransome, not only gives the domestic production as a whole and by States for the year, but presents also the latest obtainable figures for the world's production and contains information on the quantity and character of ore treated, methods of reduction, prices, imports and exports, and uses of quicksilver. The report also contains notes on the operations at individual mines and a table wherein are listed most of the quicksilver mines of the United States with notes on the character of deposit, workings, reduction equipment, and total output of each mine.

SHIPMENTS IN 1918 OF WATER WHEELS MANUFACTURED IN THE UNITED STATES.

As an index of industrial development, the sale of water wheels has some value. The following table, based on returns received by the United States Geological Survey, Department of the Interior, from practically all manufacturers of turbines and impulse wheels in the United States, indicates by States the aggregate capacity of water wheels shipped in 1918. The State indicated is that in which the wheels are intended to be installed. No information is available in regard to the importation of water wheels. In view of the war conditions in 1918 it may probably be safely assumed that there were no importations of water wheels during the year. It is of interest to note that the total horse-power of water wheels shipped during 1918 for the three States of Georgia, South Carolina, and Tennessee is almost equal to that shipped to all the other States.

State.	Horse-power.	State.	Horse-power.
Alabama	1,650	New Jersey	565
Arizona	1,049	New Mexico	93
California	5,780	New York	50,851
Colorado	297	North Carolina	2,826
Connecticut	922	Ohio	245
Delaware	247	Oregon	5
Georgia	21,10[illegible]	Pennsylvania	921
Idaho	7,924	Rhode Island	1,330
Illinois	4,810	South Carolina	108,435
Iowa	45	Tennessee	55,373
Kansas	1,200	Utah	9,134
Kentucky	37	Vermont	3,962
Louisiana	95	Virginia	806
Maine	9,231	Washington	5,565
Maryland	548	West Virginia	3,632
Massachusetts	23,417	Wisconsin	10,187
Michigan	16,462		
Minnesota	29,621		387,843
Montana	205	Exported	108,376
Nebraska	836		
Nevada	220		496,219
New Hampshire	8,210		

Digitized by Google

ARTICLES IN CURRENT PERIODICALS.

American Journal of Botany, for October; *Brooklyn Botanic Garden, Brooklyn, N. Y. $5.00 per year. 60 cents a copy.* "Venation and Senescence of Polyembryonic Citrus Plants," M. R. Ensign; "A Study of Some Factors in the Chemical Stimulation of the Growth of Aspergillus Niger," Robert A. Steinberg.

Geographical Review for December; *Broadway at 156th Street, New York City. $5.00 per year, 50 cents a copy.* "German Colonization in Eastern Europe," Jean Brunhes and Camille Vallaux, (1 map); "The Western Maracaibo Lowland, Venezuela," Theodoor de Booy, (1 insert map in color, 13 photos); "A Combined Map and Panorama for Orientation from Lookout Stations," Emanuel Fritz, (1 insert plate, 2 photos); "The Indians of the Great Lakes Region and Their Environment," A. E. Parkins.

Journal of Geography for November; *Broadway at 156th Street, New York City; $1.00 per year, 15 cents a copy.* "Southeastern Utah: A Study of an Arid Region," Malcolm Rutherford Thorpe, "Status of Geography in Normal Schools of the Far West," Clyde E. Cooper; "Our Geography Correspondence," Jehiel S. Davis.

Literary Digest for December 6; *New York City; 10 cents a copy.* "Are the Coal Operators Profiteering?" "How to Save the Treaty;" "Silver Power '16 to 1';" "Europe's Money in a Sinking Well;" "The Farmer Will Have His Own Now;" "America's Abandonment of Europe." For December 13, "Our New Grievance Against Mexico;" "The President on Labor Unrest;" "Down to Facts in the Coal Fight;" "Ellis Island Gates Ajar;" "The New Labor Party."

National Geographic Magazine for December: *Washington, D. C.; $3.00 per year, 35 cents a copy.* "The Romance of Military Insignia," 27 illustrations, Robert E. Wylie; "American Decorations and Insignia of Honor and Service," 124 illustrations; "Celebrating Christmas on the Meuse," 5 illustrations, Clifton Lisle; "The Camel of the Frozen North," 19 illustrations, Carl J. Lomen.

Photo-Era for November, *Boston, Mass.; $2.00 per year, 20 cents a copy.* "Gloucester the Picturesque," Herbert B. Turner; "Improving a Snapshot," William S. Davis; "The Ethics of Specimen-Prints," The British Journal; "Cobweb-Photography," Beatrice B. Bell; "The Ship Mayflower," Wilfred A. French; "The Secret of Beautiful Photography," Ward Muir.

Popular Astronomy, for December; *Northfield, Minn., $4.00 per year.* "The 100-Inch Hooker Telescope of the Mount Wilson Observatory," with Plate XLIX, George E. Hale; "The Reform of the Julian Calendar," Roscoe Lamont; "Motion of a Particle About a Circular Disc," F. J. B. Cordeiro; "An Intensely Red Variable Star," with Plate L, J. A. Parkhurst; "The Flash Spectrum of June 8, 1918," concluded, H. G. Wilson; "Twenty-third Meeting of the American Astronomical Society," continued, with Plates LI and LII.

School Review, for December; *University of Chicago Press, $1.50 per year, 20 cents a copy.* "Supervisory Leadership on the Part of the High-School Principal," Franklin Bobbitt; "The Measurement of Physics Information," J. Crosby Chapman; "Character and Value of Standardized Tests in History," Earle Underwood Rugg.

Scientific Monthly, for December; *Garrison, N. Y., $5.00 per year, 50 cents a copy.* "The Mechanism of Evolution in the Light of Heredity and Development," Edwin G. Conklin; "Our Universe of Stars," Eric Doolittle; "Individuality in Research," R. D. Carmichael; "The Romance and the Tragedy of Sneezing," Dr. Wilson D. Wallis; "Physiological Inertia and Physiological Momentum," D. F. Harris; "The Origins of Civilization," James H. Breasted; "Natural Death and the Duration of Life," Dr. Jacques Loeb.

Digitized by Google

PROBLEM DEPARTMENT.

Conducted by J. O. Hassler.

Crane Technical High School and Junior College, Chicago.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. If you have any suggestion to make, mail it to him. Address all communications to J. O. Hassler, 2337 W. 108th Place, Chicago.

SOLUTION OF PROBLEMS.

621. *Proposed by Louis Sklar, Philadelphia, Pa. (Corrected version.)*

Solve:
$$y^2-z^2+2xy+2xz = 5 \quad (1)$$
$$x^2-y^2+2yz-2xz = -5 \quad (2)$$
$$2x+y-z = 1 \quad (3)$$

I. *Solution by Walter R. Warne, State College, Pa.*

From (1),
$$(y+z)(2x+y-z) = 5 \quad (4)$$
Dividing by (3),
$$(y+z) = 5 \quad (5)$$
From (2),
$$(x-y)(x+y-2z) = -5 \quad (6)$$
(3)+(5) gives
$$(x+y) = 3 \quad (7)$$
From (5), (6), (7),
$$(2x-3)(2x+1) = 5 \quad (8)$$
Obviously, now, $x = 2, -1$; $y = 1, 4$; $z = 4, 1$ which, as paired, check.

II. *Solution by M. G. Schucker, Pittsburgh, Pa.*

Arranging terms to show the difference of two squares,

(1) becomes
$$(x^2+2xy+y^2)-(x^2-2xz+z^2) = 5. \quad (4)$$
(2) becomes
$$(x^2-2xz+z^2)-(y^2-2yz+z^2) = -5. \quad (5)$$
(3) may be written
$$(x+y)+(x-z) = 1. \quad (6)$$
Dividing (4) by (6)
$$(x+y)-(x-z) = 5 \quad (7)$$
and $x+y = 3, x-z = -2, y+z = 5, y-z = \pm 3$
$x = -1$ or 2; $y = 4$ or 1; $z = 1$ or 4.

[The following solution refers to the incorrect version of the problem which had $2yz$ instead of $2xz$ in equation (1).—*Editor.*]

III. *Solution by A. Pelletier, Ecole Polytechnique, Montreal, Can.*

Eliminating y and z from the system we obtain the equation
$$8x^3-43x^2+36x+52 = 0.$$
By Sturm's theorem we find that it has three real roots, two positive and one negative; the positive are between 2 and 3, 3 and 4; the negative is between 0 and -1. By Horner's method, I found $x' = 3.661-$, $x'' = 2.442-$, $x''' = -.727+$; then we easily get the corresponding values of y and z. I found $y' = 3.252-$, $y'' = -4.616+$, $y''' = 2.739$ and $z' = 9.573$, $z'' = -.733+$, $z''' = .285$.

Solutions were also received from N. Barotz, R. C. Staley, A. Pelletier *(corrected version). One unsigned solution was received.*

622. *Proposed by A. Pelletier, Montreal, Can.*

For what values of x will x^3+x be a square? Give a systematic procedure to derive these values.

Digitized by Google

I. *Solution by R. T. McGregor, Elk Grove, Cal.*

Let

$$x^2+x = (x-a)^2.$$

From this equation

$$x = a^2/(1+2a),$$

and by assigning at pleasure different values of a, we obtain the required values of x.

II. *S. H. Parsons, Paris, Ontario,* notes at the close of a solution similar to the above that for integral values of a, the series of values of x is

$$\cdots \quad -3^2/-5, \ -2^2/-3, \ -1^2/-1, \ 0^2/1, \ 1^2/3, \ 2^2/5, \ 3^2/7, \quad \cdots$$

III. *The Proposer submitted the following statement without indicating method used to obtain it.*

The identity

$$[(k-\tfrac{1}{2})^2/2k]^2+(k-\tfrac{1}{2}^2)/2k = [(k^2-\tfrac{1}{4})/2k]^2$$

solves at once the problem. We make $x = (k-\frac{1}{2})^2/2k$, in which k is any rational number.

IV. *Solution by N. Barotz, New York City.*

Let $x = a/n$ (where a and n are any rational numbers.)
then: $a^2/n^2+a/n$ must be a square.
or: $(a^2+an)/n^2$ must be a square.
This will be true if a^2+an is a square.
Let: $a^2+an = m^2$ (m is any rational number.)
then $n = (m^2-a^2)/a$
Therefore: $a/n = a^2/(m^2-a^2) = x$.

To find values of x, substitute values for a and m in the above formula. Unless a or m are irrational, x^2+x will be a square.

V. *Remarks by the Editor.*

Solutions I. and III. are of the same type, the parameters a and k being connected by the relation $a = k-\frac{1}{2}$, or $a = (\frac{1}{2}-k)/2k$. Neither solution will hold for all rational values of the parameter as indicated by the author. I. is impossible when $0>a>-1$ and III. when $\frac{1}{2}>k>-\frac{1}{2}$. Similarly the solution of IV. does not hold if $0>a^2/(m^2-a^2)>-1$, or if a and m are connected by the relation $a^2(1-\epsilon)+m^2 = 0$, where $0<\epsilon<1$. The graph of $f(x) = x^2+x$ shows that these values mentioned correspond to that value of the function which is negative (or below the X-axis).

One incorrect solution was received.

623. *Proposed by C. E. Githens, Wheeling, W. Va.*

The three roots of a cubic equation are $\cos 20°$, $-\cos 40°$ and $-\cos 80°$. Required the equation.

Solution by A. Pelletier, Montreal, Can.

Let $x^3+ax^2+bx+c = 0$ be the required equation, in which a, b, c are to be determined. If r_1, r_2, r_3 are the roots, we know that

$$a = -(r_1+r_2+r_3), \ b = r_1r_2+r_2r_3+r_3r_1, \ c = -r_1, r_2, r_3,$$

hence,
$$a = \cos 40°+\cos 80°-\cos 20° = 2\cos 60°\cos 20°-\cos 20° = 0;$$
$$b = -\cos 20°\cos 40°+\cos 40°\cos 80°-\cos 20°\cos 80°$$
$$= -(\cos 60°+\cos 20°)/2+(\cos 120°+\cos 40°)/2 - (\cos 100°+\cos 60°)/2$$
$$= -3/4+(\cos 40°+\cos 80°-\cos 20°)/2$$
$$= -3/4;$$
$$c = -\cos 20°\cos 40°\cos 80° = -\cos 20°/2(\cos 120°+\cos 40°)$$
$$= -\cos 20°/2(2\cos^2 20°-3/2) = -1/4(4\cos^2 20°-3\cos 20°) = -1/4\cos 60° = -1/8.$$

Therefore, the required equation is $x^3-3/4x-1/8 = 0$.

Solutions were received from N. Barotz, M. G. Schucker *and the* Proposer.

624. *Proposed by J. Carl Kamplain, Student, Crane Junior College, Chicago.*

Digitized by Google

To determine a point such that its distance from the vertices of a given triangle are inversely proportional to the sides of the triangle opposite the respective vertices.

I. *Solution by A. Pelletier, Montreal, Can.*

Let ABC be the given triangle, and h_a, h_b, h_c its three heights. Find two points M and N dividing BC internally and externally in the ratio $h_b : h_c$, and describe the circle having MN for diameter. Likewise, take M′ and N′ dividing BA in the ratio $h_b : h_a$, and describe the circle M′N′. The two points of intersection of the circles, P and P′, answer the question.

For, $PB/PC = h_b/h_c$, and $PB/PA = h_b/h_a$, hence,
$$PA : PB : PC = h_a : h_b : h_c$$
But, $h_a : h_b : h_c = 1/a : 1/b : 1/c$, therefore,
$$PA : PB : PC = 1/a : 1/b : 1/c.$$

II. *Solution by N. Barotz, New York City.*

Construction:

(ABC is the given triangle and 0 the required point.) Construct a circle with BC as the diameter. Draw AD bisecting angle A. Let E be the mid-point of the semi-circle outside the triangle. Draw line EDF intersecting the circle in F. Draw the circle ADF. Duplicate this construction beginning with the side AC. The intersection of the resulting circle with the circle ADF, if within the triangle, is the required point, 0.

To prove the construction it should be proved that: The locus of a point the ratio of whose distances from two given points is constant, is a circle. This can easily be proved by analytic geometry.

Since AD bisects angle A, and since FD bisects angle BFC, AB : AC = FB : FC = BD : DC. Therefore the circle determined by the points A, F, and D, is the locus of all points, the ratio of whose distances from B and C is a constant equal to AB/AC. In a similar way, the second determined circle is the locus of all points whose distances from C and A are in the ratio BC/BA. Therefore the intersection of both circles, 0, is the point so situated that OB : OC = AB : AC and OC : OA = BC : BA. Or, OB,OC and OA are inversely proportional to AC, AB and BC.

625. *Proposed by Clifford N. Mills, Brookings, So. Dak.*

If from the vertices of a triangle ABC, three straight lines, AA′, BB′, CC′, are drawn to the opposite sides (or these sides produced), each equal to a given line, l, and from any point O within the triangle, Oa, Ob, Oc, are drawn parallel respectively to AA′, BB′, CC′, and terminating in the same sides, then
$$Oa+Ob+Oc = l.$$

Solution by A. Pelletier.

Join AO, BO, CO, and produce to meet BC at M, AC at N, and AB at P. We have
$$Oa/l = OM/AM = OBC/ABC;$$
$$Ob/l = ON/BN = AOC/ABC;$$
$$Oc/l = OP/CP = ABO/ABC;$$
hence, $(Oa+Ob+Oc)/l = (OBC+AOC+ABO)/ABC = 1$
Therefore, $Oa+Ob+Oc = l.$

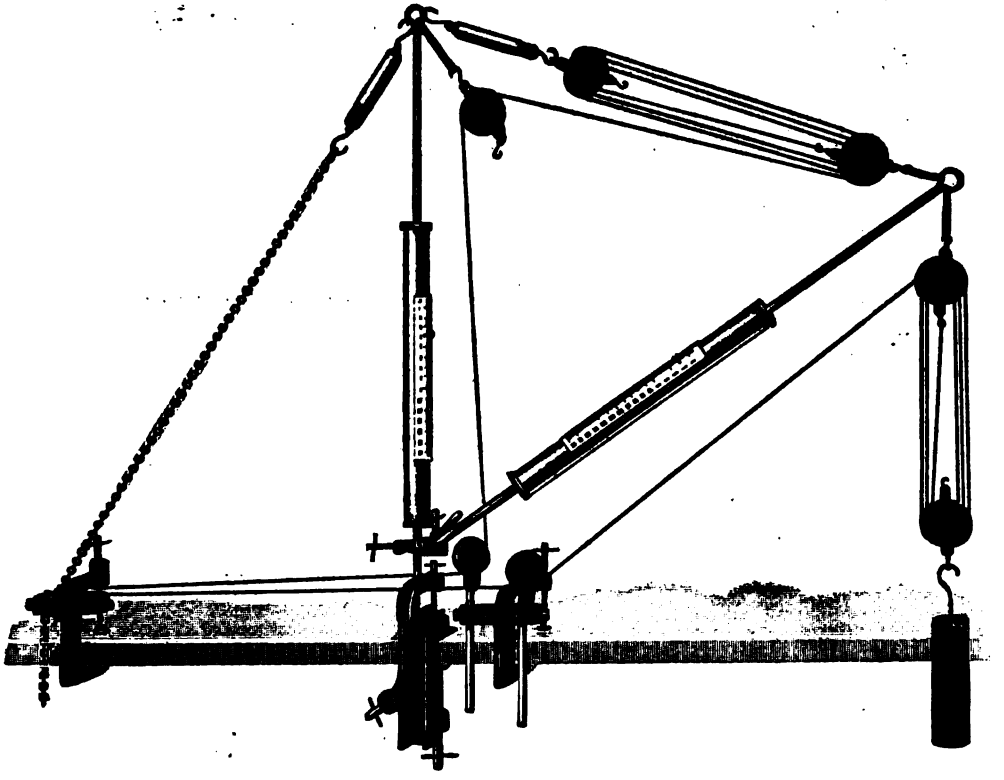
609. *Proposed by Harris F. MacNeish, New York City.*

Through a given point draw a straight line cutting a given straight line and a given circle such that the part of the line between the point and the given line may be equal to the part within the given circle.

[This was proposed in April and no synthetic method of solution has been received. The following solution by means of analytic geometry seems to be the simplest obtainable and shows that the solution of a fourth degree equation is necessary to obtain the necessary value to construct the line.—*Editor*.]

Digitized by Google

A Sign of Quality. QUALITY WELCH SERVICE A Mark of Service



COMPLETE DERRICK OUTFIT

Made Up From Standard Pieces

MAKE YOUR SCIENCE TEACHING MORE PRACTICAL AND EFFECTIVE

Quality in apparatus is your first requirement, and Service which helps you in selecting your equipment is what you appreciate most.

Write us telling us what text you use and we will send you our catalogs and lists which will give you an example of the service of our experts.

NEW CATALOGS just off the press in ***Agriculture, Biology, Physics and Chemistry, Wireless Apparatus, Text Book Lists, State Lists, Bulletins of Special Pieces, etc.***

W. M. Welch Scientific Company

Manufacturers, Importers and Exporters of Scientific Apparatus

1516 Orleans Street **Chicago, Ill., U. S. A.**

Digitized by Google

Solution by N. P. Pandya, Amreli (Kathiawad), India.

Let P be the given point, (h, k); QL $(y = l)$ the given line; $x^2+y^2 = a^2$ the given circle; PQFG $(y = mx+c)$ the required line with PQ = FG. PL$(=p) \perp$ QL.

The ordinates of F and G are the values of y given by the solution of the simultaneous equations $y = mx+c$ and $x^2+y^2 = a^2$, *i. e.*, of the equation $(y-c)^2+y^2m^2 = a^2m^2$, *i. e.*, of $y^2(1+m^2)-2cy+c^2-a^2m^2 = 0$

$\therefore$ the difference between these ordinates is

$$[2\sqrt{c^2-(1+m^2)(c^2-a^2m^2)}]/(1+m^2)$$

$$= [2m\sqrt{a^2(1+m^2)-c^2}]/(1+m^2)$$

But this difference = FGsinPQL

= PQsinPQL

$= p$

$\therefore p(1+m^2) = 2m\sqrt{a^2(1+m^2)-c^2}$.

This equation gives m; and since P (h, k) lies on $y = mx+c$, $k = hm+c$ gives c.

$\therefore y = mx+c$ is determined. —

Late Solution.

A solution to 612 was received from G. C. Williams.

PROBLEMS FOR SOLUTION.

636. *Proposed by Walter Warne, State College, Pa.*

Obtain all the values of x and y in the equations

$$x+y = 14-y^2,$$
$$x^2y^2+xy^2+xy^3 = 600-x^2y^4-2x^2y^3$$

637. *Proposed by A. Pelletier, Ecole Polytechnique, Montreal, Can.*

A, B, C are three numbers having, respectively, α, β, γ digits. Find the number of digits in the expression $(AB/C)^n$.

638. *Proposed by Walter R. Warne.*

Show that

$$\begin{vmatrix} x, & y, & z, & w \\ a, & b, & c, & d \\ d, & c, & b, & a \\ w, & z, & y, & x \end{vmatrix} = \begin{vmatrix} (x+w), & (y+z) \\ (a+d), & (b+c) \end{vmatrix} \cdot \begin{vmatrix} (x-w), & (y-z) \\ (a-d), & (b-c) \end{vmatrix}$$

639. *Proposed by N. P. Pandya, Amreli, Kathiawad, India.*

A quadrilateral ABCD has AB : BC : CD : DA = 1 : 2 : 3 : 4. On DA a part, DE, is cut off equal to 3AB. Find the condition that in the triangle BCE, CB = CE.

640. *Proposed by Walter R. Warne.*

If $\alpha+\beta+\gamma+\delta = 360°$, change the expression

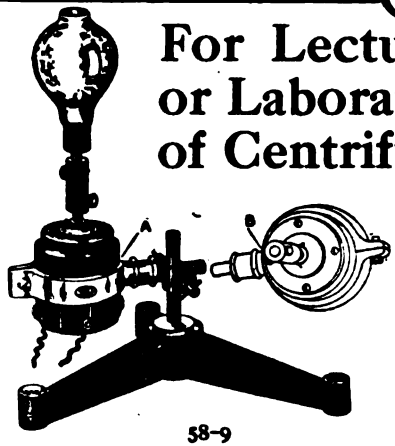
$$\cot(\alpha/2)+\cot(\beta/2)+\cot(\gamma/2)+\cot(\delta/2)$$

into a product in which δ is lacking.

USED FOR COLORING GLASS.

The production of selenium in 1918 was 103,694 pounds, valued at $206,540, an increase of 162 per cent in quantity and 195 per cent in value as compared with figures for the previous year. Of the quantity sold during 1918 about 60 per cent was used as a coloring and deoxidizing agent by the glass industry, according to the United States Geological Survey, Department of the Interior.

Digitized by Google



58-9

The Waverley-Electric
Specifications

Support—Standard Tripod.
Yoke—Cast Aluminum.
Housing—Enameled Iron.
Motor—6,000 R. P. M.
Mica Insulation. Self-Adjusting Brushes.
Ball-Bearing Shaft.
Current—D. C., A. C., or Dry Cells.
Chuck—Universal.

For Lecture Demonstration, or Laboratory Application, of Centrifugal Force . . . . .

You Need This Waverley Electric—
A Whirling Machine and Centrifuge Combined.

As a whirling machine the Waverley-Electric takes a Centrifugal Globe (as illustrated), or Double Hoops, Centrifugal Balls, and other accessories.

A Centrifuge Head converts the Waverley-Electric into a powerful centrifuge that may be used with efficacy for the analysis of milk, urine, blood, or other liquids.

The specially designed, ball-bearing motor is mounted and balanced to operate in vertical or horizontal position. Consequently its general utility includes the rotation of Savart's Wheels, Siren Discs, Newton's Color Discs and the like.

58-9 The Waverley-Electric, including Support, Yoke, Motor and Chuck.....$19.00
58-9a Waverley Centrifuge Head, four-arm.. 3.75

Cambridge Botanical Supply Company

LABORATORY EQUIPMENT—ALL SCIENCES

1-9 Lexington Street **1884-1919** **Waverley, Mass.**

DEVELOPMENT OF GROUP INTELLIGENCE TESTS.

During the war great impetus was given to the development of general mental ability or intelligence tests by their use in the examination of army recruits. A very efficient instrument for intelligence examinations exists in the Stanford revision of the Binet Scale, but for general application a test which can be given to entire groups simultaneously and scored rapidly is necessary. The army tests were designed for the adult level. Dr. F. N. Freeman and Dr. H. O. Rugg have been at work on a group test which is intended particularly for the junior and senior high school students. Two parallel forms of the test of approximately equal difficulty are approaching final form. They are printed and ready for distribution, the University of Chicago Press, at a moderate price, three cents each. This price includes instruction and scoring sheets and blank forms for the tabulation of results.

THE POTTERY INDUSTRY IN 1918.

The publication of a report on the pottery industry in 1918 has just been announced by the United States Geological Survey, Department of the Interior. This report contains a summary of the status of this increasingly important industry under war conditions, with its restrictions and handicaps, which were many and ofttimes onerous. It also contains statistics showing the growth of the industry during ten years, the production of pottery by States and kinds of ware, and the imports and exports of pottery. An interesting feature of the report is a description of the White House state dining service made and installed during the year. Especial interest attaches to this service, as it is the first American-made state service used in the White House and is known as the "Preisdent Wilson design" because of the President's interest in the design and his suggestions concerning it. A copy of this report may be obtained by applying to the Director, United States Geological Survey, Washington, D. C.

Digitized by Google

NOTES AND NEWS REGARDING THE WORK OF THE NATIONAL COMMITTEE ON MATHEMATICAL REQUIREMENTS.

A preliminary report on "The Reorganization of the First Courses in Secondary School Mathematics," prepared by a sub-committee, which was authorized to publish it, was issued on November 25. It is being made the basis of discussion by organizations, committees, local groups, etc., throughout the country. Over thirty such organizations are at present at work on this report.

The whole of the meeting of the Association of Teachers of Mathematics in the Middle States and Maryland, in Philadelphia on November 29 was devoted to the discussion of this report; it had a prominent place on the program of the Central Association of Science and Mathematics Teachers in Chicago on November 28 and 29, and at the meeting of the Association of Teachers of Mathematics in New England, in Boston on December 6.

Committees representing organizations in the following states are actively cooperating with the National Committee: Massachusetts, Rhode Island, New York, New Jersey, Pennsylvania, West Virginia, Ohio, Indiana, Illinois, Wisconsin, Iowa, North Dakota, Missouri and Texas.

Local groups or clubs are studying the report in Boston, Springfield, (Mass.), Providence, New Haven, New York City, Washington, Baltimore, Cincinnati, Columbus, (Ohio), Terre Haute, Chicago, St. Louis, St. Paul, Minneapolis and in several smaller cities.

Meetings in addition to those previously announced at which the work of the National Committee will be discussed are as follows: Mathematical Association of America in St. Louis, December 29, and in New York, January 2; Ohio State Teachers Association, Columbus, December 30; Pennsylvania State Educational Association, Philadelphia, December 30; Association of Teachers of Mathematics in the Middle States and Maryland, Southern Section, Baltimore, December 13, Syracuse Section, Syracuse, New York, December 30.

The next meeting of the National Committee will occur in New York City on December 30. The principal items on the program for this meeting are the consideration of the report on "The Reorganization of the First Courses in Secondary School Mathematics," the report on "The Valid Aims and Purposes of the Study of Mathematics" and the proposed revision of college entrance requirements.

The United States Bureau of Education has offered to publish the reports of the National Committee in the form of leaflets or bulletins.

A Mathematics Section of the West Virginia State Teachers Association was organized in Fairmont on November 28. Professor John Eiesland of the University of West Virginia was elected Chairman of the newly formed section. Professor C. N. Moore spoke in behalf of the work of the National Committee.

SCIENCE QUESTIONS.

Conducted by Franklin T. Jones.

The Warner & Swasey Company, Cleveland, Ohio.

Readers are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, 10109 Wilbur Ave., S. E., Cleveland, Ohio.

Please send examination papers on any subject or from any source to the Editor of this department. *School examinations of all sorts are wanted. If you have run across anything queer, be sure to send it in.*

Digitized by Google

Among the New Books

Schorling and Reeve's General Mathematics

For the ninth grade. A course in the fundamental facts of general mathematics in which the authors make functional thinking the organizing and unifying principle.

Wentworth-Smith's Higher Arithmetic

For high schools and normal schools. It offers the arithmetic that every citizen should know. It teaches the worth of thrift and investment.

Test and McLaughlin's Notes on Qualitative Analysis

Prepared especially for students requiring a brief course. It gives a broader knowledge of general chemistry through the exposition of the underlying principles of Ionic Theory and Mass Law.

GINN AND COMPANY

Boston Atlanta New York Dallas Chicago Columbus London San Francisco

QUESTIONS AND PROBLEMS FOR SOLUTION.

(*Please send answers to the following questions here repeated.*)

307. *Proposed by G. Ross Robertson, Riverside, Cal.*

Why is the rust, or tarnish, or corroded surface of common lead, grey or black? (The oxides of lead are yellow, red, or brown.)

317. *Proposed by J. C. Packard, Brookline, Mass.*

An automobile, weighing with load 1,000 lbs., while running at the rate of 5 miles an hour collides with a telegraph pole. The fender is crushed in about 2 inches. How heavy a blow did the auto deliver?

[Query: Is this the piledriver problem in another form?—EDITOR.]

330. *The fly and spider problem.* (*See November, 1919.*)

(Only one correct solution has been received.)

335. *Proposed for Solution by W. L. Malone, Tacoma, Wash.*

"If a man can jump 3 feet high on the earth, how high could he jump on the moon, where g is $\frac{1}{6}$ as much?"

(First Course in Physics, page 94, Revised Edition. Millikan and Gale.)

SOLUTIONS AND ANSWERS.

328. *Proposed to boys in The Warner & Swasey Apprentice School by Mr. Worcester R. Warner.*

The Panama Canal Locks at Gatun are in a series of three, each 1,000 feet long and 110 feet wide. Each of the three locks raises or lowers a ship 28 feet.

Gatun Lake is, therefore, 84 feet above sea level.

It is desired, first, to determine the quantity of water required to take each ship—one at a time—from the Caribbean Sea into Gatun Lake; and, second, the quantity of water required to return each ship—one at a time—from the lake to the Caribbean Sea again.

Answers are required in tons, computed by the following formula:

Cubic feet of water X.028 = tons.

Let us suppose a ship has just come down from Gatun Lake to the Caribbean Sea. The ships "A" and "B" are waiting to be taken from the sea to Gatun Lake, and back to the sea again, "B" to follow "A" in each direction.

Digitized by Google

Question 1: How much water must be taken from the lake to take "A" from the sea into the lake?
Question 2: How much water must be taken from the lake to take "B" from the sea into the lake?
Question 3: How much water must be taken from the lake to take "A" from the lake to the sea?
Question 4: How much water must be taken from the lake to take "B" from the lake to the sea?
The displacement of these ships is 35,000 tons each.
Another solution to 328. What is the matter with it?
Question 1: A to lake from sea. $(3\times86{,}240)+35{,}000 = 293{,}720$ tons. } up.
Question 2: B to lake from sea. $293{,}720-(2\times86{,}240) = 121{,}240$ tons. } up.
Question 3: A from lake to sea. None taken from lake.
Question 4: B from lake to sea. $86{,}240-35{,}000 = 51{,}240$ tons. } Down.
More answers to 328.
A—up 188,720 tons.
B—up 86,240 tons.
A—down none.
B—down 51,240 tons.

EXAMINATION PAPER.

Brown University

EXAMINATION FOR ADMISSION.

Physics.

September 21, 1918.

Omit three questions. The reasoning by which numerical results are obtained must be clearly stated.

1. State Archimides' Principle. Describe two methods by which it may be utilized to find the density of a body.
2. A stone attached to the end of a string two feet long is whirled in a vertical circle at a uniform rate of ten revolutions per second. Is the velocity of the stone constant or accelerated? If the string breaks when the stone is at the top of the circular path, what is the direction and magnitude of the velocity of the stone?
3. If the center of the circular path in problem two is four feet above a level road, how far will the stone travel before it strikes the ground? Acce eration due to gravity is 32.2 feet per second.
4. A base ball pitcher delivers the ball in one second with a velocity of 100 feet per second. If the ball weighs seven ounces, how much power does he develop? One horse-power is equivalent to 550 foot-pounds per second.
5. What holds the ink on a common writing pen? Why does the pen not work well when handled with the fingers before it is dipped in ink? Why will it not mark well on glazed paper or on greasy paper?
6. Explain some method by which a clock pendulum can be compensated for changes in temperature so that the clock will keep correct time at any ordinary temperature.
7. A small compass is placed under an electric light wire suspended horizontally in the magnetic meridian. The north pole of the compass points west. What is the direction of the current in the wire?
8. A man standing on a corner noticed that his shadows cast by two ark lights appeared equally dark. One of the lights was 50 feet from the man and the other was 100 feet from him. What was the relative intensity of the two lights? Which was the more intense?
9. An electric water heater operates on five amperes when connected to a 100 volt circuit. If the price of electric power is ten cents per kilowatt hour, what will it cost to heat one liter of water from twenty degrees centigrade to the boiling point? How long will it take? One caloric is equivalent to 4.2 watt-seconds.

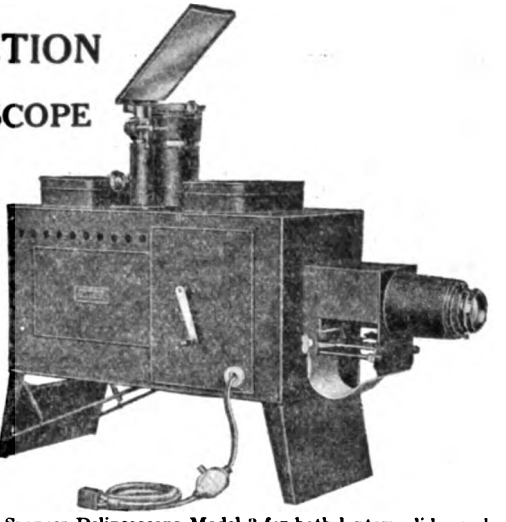
Digitized by Google

VISUAL INSTRUCTION
WITH
SPENCER DELINEASCOPE MODEL 3

is made perfect because it is an IDEAL STEREOPTICON for both lantern slides and opaque objects, such as pictures, post-cards, reading matter and objects of all kinds dead and alive.

IDEAL, because it embodies basic ideas (patented) possessed by no other. Example: Mechanical means of handling the slides, which does away with the antiquated lantern-slide holder and at the same time gives a "dissolving effect" on the screen unattained with other outfits except by using two stereopticons, one above the other.

One Spencer Delineascope does it.



Spencer Delineascope Model 3 for both lantern slides and opaque objects. 1,000 Watt Masda bulb illuminant. **Price, $150.00**

SPENCER BUFFALO U.S.A.

SPENCER LENS COMPANY
Buffalo, New York

Manufacturers of **Microscopes, Microtomes, Delineascopes, Optical Glass, Scientific Apparatus, Etc.**

SPENCER BUFFALO U.S.A.

Kalato Laboratory Filter Paper

Suitable for all analytical purposes other than those requiring the use of a paper extracted with Hydrochloric and Hydrofluoric acid. Filters rapidly and retains the finest precipitates. Weight of ash 3 in. circle, 0.012 gm. Sample sent on request.

Complete Supplies for Chemistry, Biology and Physics

Let us quote prices on your next list of requirements

THE KAUFFMAN - LATTIMER CO.
44-46 East Chestnut Street
COLUMBUS, OHIO

Digitized by Google

BOOK REVIEW.

Qualitative Analysis, by J. O. Frank, Department of Chemistry, Wisconsin State Normal School, Oshkosh, Wis. Second Edition. Pp. 36, 14.8x 22.2x.3 cm. Flexible board binding. 1919. 50c wholesale; with chart 60c. Published by the author, at Oshkosh, Wis.

An inexpensive laboratory guide, understandable to the student in the High School and covering only the fundamentals of qualitative analysis. The outlines of the work only are given in the manual, it being understood that the explanation of the procedure will be given later by the teacher or larger works referred to for equations and the theory. The author believes in having his pupils learn things by doing them and therefore puts them to work in the laboratory first. As he himself says, "The work first; theories, laws, precautions, explanations, etc., afterwards." A chart giving a suggestive outline for systematic analysis of salts may be had with the manual for ten cents extra. Pages 10 to 18 give valuable "Notes on the separation and identification of the metals." These are all the book affords in the way of explaining the why of the processes. The author also leaves it to the teacher to treat the subject from the viewpoint of the ionic theory, specifically suggesting in the preface, however, that this should be done. F. B. W.

BOOKS RECEIVED.

Applied Science for Wood-Workers, by William H. Dooley, Principal of New York Textile School. Pages x+457. 13.5x19 cm. Cloth. 1919. The Ronald Press Company, New York.

An Introductory Course in Quantitative Chemical Analysis, by George McPhail Smith, University of Illinois. Pages xi+206. 15x22 cm. Cloth. 1919. The Macmillan Company, New York.

The Principles of Agriculture, by John H. Gehrs, Normal School, Cape Girardeau, Mo. Pages x+594. 13.5x19 cm. Cloth. 1919. $2.25. The Macmillan Company, New York.

Exercises in Chemistry, by William A. Noyes, Director of the Chemical Laboratory, and B. S. Hopkins, University of Illinois. Pages vi+131. 12.5x19 cm. Paper, 1919. Henry Holt and Company, New York.

Number by Development, Parts I and II, by John C. Gray, Superintendent of Schools, Chicopee, Mass. Part I. Pages xxii+486. 13.5x 19 cm. Cloth. 1919. Part II, xx+514. 13.5x19 cm. Cloth, 1919. J. B. Lippincott Company, Philadelphia.

Teaching Home Economics, by Anna M. Cooley, Cora M. Winchell, Wilhemina H. Spohr, and Josephine A. Marshall. Teachers College, Columbia University. Pages xii+555. 13.5x20 cm. Cloth. 1919. $1.80. The Macmillan Company, New York.

College Textbook of Chemistry, by William A. Noyes, Director of the Chemical Laboratory. The University of Illinois. Pages vii+370. 13.5x19.5 cm. Cloth. 1919. Henry Holt and Company, New York.

Applied Science for Metal-Workers, by William H. Dooley, Principal of New York Textile School. Pages x+479. 13.5x19 cm. Cloth. 1919. The Ronald Press Company, New York.

TIN MINING IN SEWARD PENINSULA.

Stream tin, a form of cassiterite, the most valuable ore of tin, has been found in many streams in Alaska, and lodes of cassiterite have been prospected and mined at several places in the Territory. An account of the tin deposits and tin mining in Seward Peninsula is given by G. L. Harrington in Bulletin 692-G, which contains descriptions of the lodes and placers mined.

Digitized by Google

375.05
S37
S4

Vol. XX. No. 2 Whole No. 166

FEBRUARY 1920

SCHOOL SCIENCE AND MATHEMATICS

A Journal for All Science and Mathematics Teachers

Founded by C. E. Linebarger

SMITH & TURTON, Publishers

Publication Office, Mount Morris, Illinois

CHICAGO OFFICE, 2059 East 72nd Place, CHICAGO, ILL.

CHARLES H. SMITH
EDITOR
Hyde Park High School, Chicago

CHARLES M. TURTON
BUSINESS MANAGER
Bowen High School, Chicago

DEPARTMENTAL EDITORS

Agriculture—Aretas W. Nolan
The University of Illinois, Urbana, Ill.
Astronomy—George W. Myers
The University of Chicago
Biology, Research in—Homer C. Sampson
The Ohio State University, Columbus
Botany—Worrelo Whitney
Hyde Park High School, Chicago
Chemistry—Frank B. Wade
Shortridge High School, Indianapolis, Ind.
Chemistry, Research in—B. S. Hopkins
The University of Illinois, Urbana, Ill.
Earth Science—William M. Gregory
Normal Training School, Cleveland, Ohio
General Science—Fredric D. Barber
State Normal University, Normal, Ill.
Mathematics—Herbert E. Cobb
Lewis Institute, Chicago
Mathematics Problems—Jasper O. Hassler
Crane Technical High School and Junior College, Chicago
Physics—Willis E. Tower
Englewood High School, Chicago
Physics, Research in—Homer L. Dodge
The State University of Oklahoma, at Norman. Representing American Physical Society
Science Questions—Franklin T. Jones
Warner and Swasey Co., Cleveland, Ohio
Zoology—

Published Monthly October to June, Inclusive, at Mount Morris, Illinois
Price, $2.50 Per Year; 30 Cents Per Copy

Entered as second-class matter March 1, 1913, at the Post Office at Mount Morris, Illinois, under the Act of March 3, 1879

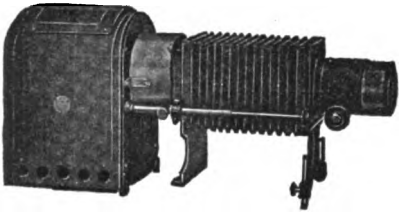
Digitized by Google

"McIntosh Lanterns Are Honest Lanterns."

Lantern Slides of Science

A copy of our Catalogs of science slides was mailed when published to every member of the Central Association. Are you a member? Did you get your copy? Did you keep it?

If not, there is another copy for you if you are interested. Just write us a card and ask for it. No obligation. You'll need it in placing your orders for science slides.



Lanterns from $36.00 up. Opaque and micro projectors, slides and accessories.

McINTOSH STEREOPTICON COMPANY
410 Atlas Block, CHICAGO, ILL.

For Next Semester

Moore and Halligan—PLANT PRODUCTION
—Agronomy and Horticulture

Mayne and Hatch—HIGH SCHOOL AGRICULTURE
—General Treatment

Coulter—PLANT LIFE AND PLANT USES
—Practical Botany—Not too Technical

Hunter—CIVIC BIOLOGY
—Community Welfare

Dryer—HIGH SCHOOL GEOGRAPHY
—Physical—Economic—Regional

Clark—INTRODUCTION TO SCIENCE
—A real general science.

New York
Chicago
Cincinnati
Boston
Atlanta

AMERICAN BOOK COMPANY
330 East Twenty-second Street
CHICAGO, ILLINOIS

Digitized by Google

SCHOOL SCIENCE AND MATHEMATICS

VOL. XX, NO. 2 FEBRUARY, 1920 WHOLE NO. 166

SCIENCE AND HUMANISM.[1]

BY DR. LYNN H. HOUGH,

President, Northwestern University, Evanston, Ill.

I have a feeling of rather dangerous temerity in attempting to discuss the subject of Science and Humanism, because I know perfectly well that systematic walling apart has made it the proper thing to talk about science to scientists and about humanism to humanists. The ideal talker is the man who, when talking to a mathematician, makes him feel that his is the real vocation, and when talking to teachers of chemistry and biology, that they are the only men of importance, or finally upon going into the English department, makes the members feel that here at last he has found a group who strike a really responsive chord in his soul. The great difficulty of my subject this morning is that it will not allow subtle camouflage of opinion. I am going to talk about humanism to a group interested primarily in science, which is a difficult thing to do. Therefore, I wish to ask you to help me; I wish to place some of the responsibility on your shoulders.

Now, I am sure that all of us realize that there are two main moods which persist through the whole history of intellectual life. Sometimes one mood is dominant, sometimes the other, and at times one flows like a great river beneath the surface only suddenly to crop out. I suppose we get it in a very primitive stage when in the sixth century before Christ, Thales attempted to explain that everything came from one. Doubtless he had observed that when you heat water something happens that causes the water to disappear, and he may have had some intimation of the fact that it existed in steam; he may have known that water was both solid and liquid. He wanted something by which he could explain everything simply. That is the mood back of all scientific thinking.

[1]Delivered before the General Meeting of the Central Association of Science and Mathematics Teachers, Lake View High School, Chicago, November 28, 1919.

Digitized by Google

In the fifth century B. C. Protagoros rose to declare that the individual man is the important thing. What is back of all this? One feels that even in this early Greek thought life had been solidified, and that the independent human spirit was trying to get a larger breathing space. It is the cry for the manifold.

Now, the scientists belong to the conservative group. With them it is uniformity rather than diversity. Through many long years there was a battle between the traditionalists and the scientists, a battle for freedom, but today you do not have to fight for a hearing, you do not have to do battle to get students to enter your classes. If there is anything that is obvious it is that the man who is teaching any science is teaching something that is needed. The world is waiting for what you are doing.

It is a wonderful thing to be connected with that type of intellectual activity which is working for a ripe world. The war produced a situation in which the men who had scientific knowledge were the valuable men. So that on the surface, at least, it is true that you have everything which could be desired. One of the old biologists tells that whenever he arrived at a place where he could go on he found a sign reading "No thoroughfare." You do not find this so today. Your battle for recognition has been fought and won. Today the teacher of science is the absolute king of the field. So thoroughly has this become true that we find a tendency to change humanism into science, a tendency to transform humanism into something that at least looks scientific. The ordinary teacher of humanism tries to explain that humanism is a kind of science.

Samuel Crothers wrote an essay on "Protective Coloring in Education." He says that if a man wants a hearing he must wear the protective coloring of science in order to get it. Now what is under it all? Is it true that it would be a good thing if humanism would disappear from the world? I know that if I were now addressing a group of old-fashioned English teachers, their faces would light up after this remark. They would feel that a champion for their cause had arisen. But from the standpoint of the teachers of science and mathematics, is it a good thing for the intellectual life of the world to have humanism disappear? Is life just a circle, the center of which is expressed by uniformity, or is life an ellipse, with uniformity as one focus and freedom as the other? If the whole life of man is a circle with uniformity as the center, then the modern scientific viewpoint is right, but if life is an ellipse, then without being in the least disrespectful, we do

Digitized by Google

need a readjustment of the meaning of free movement in the intellectual life of the world.

I wish, however, to pay my disrespects to the humanists. I know that often in humanism you have simple and irrelevant thought, failure to classify experiences, substitution of interest for truth and of camouflage for candor. You will see that I am not unaware of the weaknesses of that side. But will you be brave enough to let me say a word on the other side—on the weaknesses of the type of mind whose one emphasis is on uniformity? You will reduce life to an intellectual commonplace. That sense of freedom of movement will disappear from the world. Life will be reduced to something dead. I think a good deal of that sort of thing happened in Germany before the war. An insatiable desire for classification, unsurpassed in the whole world, but when finally tested, how impracticable it was.

The actual question is this? How are we going to keep our emphasis on law and uniformity and yet have that resiliency of the mind that will be capable of original inventive leadership in the world? I think the answer is the scientific humanist. Every teacher of science should be also a humanist, and every teacher of humanism a scientist.

Now it is very interesting to note the reaction of the world in the latter part of the nineteenth century. One of our great writers and thinkers came out and said that he believed in fairies. What did he mean by that sort of thing? He meant this, that he was so tired of a world completely mastered by uniformity that he was going to say just exactly what he wanted to. It was the cry for room. But if we want to get away from this intellectual anarchy, do we want on the other hand to become intellectual slaves? In other words, the only safe world is one in which you have uniformity believing in individual initiative. Where are you going to get your contact? I think one thing clearly represents the problem of the teacher of science. Take for instance, the men who are working in modern astronomy. In that field two distinct factors are brought into play: one is the physical formation that they discover; the other is the amazing freedom of the mind which made the discovery possible.

Now I know this is doleful, but it is true that today we have young men coming out of our colleges who can be trusted to collect and classify material, but when you ask them to sit down and project their mind into doing something beneficial to the world, you will find that these typical products are nothing but double-

Digitized by Google

entry bookkeepers, perfectly incapable so far as originality and profound leadership are concerned.

If this is true, then these things I have said suddenly become very interesting. Uniformity is a great thing, but if it reduces men to uniformness, it is a dangerous thing. What are we going to do about it? Well, I think there is just one thing but it is the really important thing. Take a teacher of science in a certain school or college who does take time to be interested in free play so that somehow he gives the impression that while it is true that man is in a vast network of law, there is nevertheless something in that man which can master and move freely the elements of law. When you get that humanism into science, you have a wonderful thing. I believe a man like this has the situation in his hands—a scientific humanist. He is a teacher who knows his particular field, who knows the sources—material and the total literature of his department; he is a man who has mastered what has been done and who has an interest in moving forward, but with all that he is finding time to pour into his life the richness of the great poetry of the world and the philosophical theories of life; and when he does that, two things happen. First, this miracle: he teaches science as if he were a humanist; and secondly, he produces a student who has in him all the uniformity which is the basis of science and all the freedom which is the basis of humanism. It is because you can do this that I have said these things so seriously to you this morning.

OIL DRILLING IN ALASKA.

The petroleum produced in Alaska is derived wholly from a single patented claim in the Katalla oil field, according to the U. S. Geological Survey, Department of the Interior. The old wells on this claim and the refinery were operated as usual in 1918. Two new productive wells were also drilled in the Katalla field. The total production in 1918 was somewhat larger than in 1917.

There has been a revival of interest in the potential Alaskan oil fields during the year in anticipation of the expected passage of a law providing for the leasing of the Alaskan oil lands. It is reported to the Geological Survey that investigations of the supposed oil lands on the Alaska Peninsula were made during the summer of 1918. No legal provision has yet been made for the leasing, and the Alaskan oil lands are still withdrawn from entry. There was some drilling for oil in the crystalline rocks near Cape Nome in the summer of 1918, but the results were unfavorable, as was to be expected. At Seward some interest was aroused over the discovery of inflammable gas issuing from the mud and water at several localities in the swamps along the railroad. The rocks near these localities, as described in 1915 by U. S. Grant, of the Geological Survey, are slates that have been metamorphosed and folded to a degree which makes it impossible for accumulations of oil or gas to be retained in them.

Digitized by Google

PRESENT NEEDS OF SCIENCE INSTRUCTION IN SECONDARY SCHOOLS.[1]

By ROBERT A. MILLIKAN,
The University of Chicago.

After more than two years of entire absence from the active pursuit of educational matters, it is a real delight to me to be back here in touch with our common problems. We are all exceedingly happy to be through with our war jobs and yet the war did one big thing for many, particularly for those of us who had the opportunity to be in the service with which I was connected, namely, the aviation service. It gave us a chance to get away from the details of our surroundings and to look things over from the point of view of the bird. And if we could glimpse our educational problems too from an airplane I think some of us would see things in a new light. I know that I am not expressing merely an individual opinion when I say that there is a general conviction that something more is needed in our science instruction in the secondary schools than we now have, and I want to give you in ten minutes here what I think this need is.

In the November number of *The Atlantic*, Mr. Dallas Love Sharp says, "We live on and learn, but the lessons from seventeen to seventy are only a review and an application of those from six to sixteen. In any rational survey of education, therefore, the higher schools and colleges are negligible. Our education as a people is that of the secondary schools. In them, more than in any other American institution, more than in all other American institutions, are the issues of an enlightened national life; issues no longer national merely, for the war has made them vital to the life of the world." Never were truer words spoken, and it is because I believe that they are true that I have come here to make a plea. But I wish to go a step farther than Mr. Sharp and consider what at least one of these issues is. I shall speak of only one, but that one is of paramount importance. It is the place of science in our educational scheme.

Everyone will agree that this is an age whose tap root is found in the sciences, that it is an age in which that nation which is most effective in ferreting out nature's secrets and in applying them to her industries and her commerce takes the lead in every line of human endeavor. And yet we in America have not begun as yet to awaken to our need and our opportunity. We are still

[1]Read before the General Meeting of the Central Association of Science and Mathematics Teachers, Lake View High School, Chicago, November 28, 1919.

Digitized by Google

scientifically asleep. We have neither as yet developed our proportion of outstanding scientists, nor have we cultivated as high a public appreciation of science as is found in most European countries, and as we must cultivate if we are to keep our place in the vanguard of progress. *We must look primarily to the secondary schools to change this state of things.* The time is more auspicious now than it has ever been for effecting a change. The great war has waked the world to the need of more thorough work in the sciences. Every man in the service found that he needed his science in order to get ahead. The industries are finding that they need it and are calling for men who know their science. I was in charge of the Meteorological Service in the United States Army, and we had many requests from colleges, universities and some secondary schools, asking what kind of courses should be given in order to train men for the Meteorological Service. We said, "Give them some fundamental physics and mathematics, and we will do the rest." Our manufacturers, a great many of them, are expressing the same point of view. I have talked with many of them. They say, "We want not so much men who are ready to be immediate producers in our industry, as men who have a fundamental knowledge of chemistry, physics and mathematics. With these as a basis we can soon teach the men what we want them to do." In response to this demand every university of which I know has nearly doubled this year the registration in physics and chemistry which it had before the war.

The time is ripe, then, for eliminating the weaknesses of our science instruction in the secondary schools, and a first step toward the solution is a recognition of what the weakness is. But this seems to me so obvious that it is almost trite to mention it. It is simply, as I see it, that the average pupil who goes through high school does not get enough fundamental science, and what little he does get is woefully superficial and scrappy; apparently it has become more so within the past ten years. I suspect that thoughtful men the country over are fairly unanimous in thinking that the whole of our secondary school work is in danger of becoming too largely a mass of *fragments* of knowledge, and so far as science is concerned, there is no doubt about it. We have been intensively pursuing what I called in an address before the Physics Section in 1916 the pellet method of instruction in science, and we shall continue to pursue it unless you or I or somebody gets hold of our principals and superintendents and

Digitized by Google

educational leaders and wakes them up to the tremendous need and the incomparable opportunity in science.

Need and opportunity for what? First, need and opportunity to get *consecutive, systematic, thorough* work in science in the high school. This is, I think, primarily a matter of *school administration and organization*, and I hope that some time principals and superintendents will wake up to that fact. So long as they continue to do what is called in the service "passing the buck" and put it all up to the teacher of science who is altogether helpless without them, no progress can be made. *So long as our elementary science is put up in tabloid form, by which I mean that the science is split up into yearly or half-yearly doses without antecedents and without consequents or continuity, we shall never have the most worth-while science in the public schools, no matter what the angle of approach, or what the arrangement of subject matter.* The crying need is not for a reorganization and rearrangement of the subject matter of science. That has been done and redone every year for twenty years to no avail and it will continue to be done to no purpose until we get a reorganization of the curriculum which makes it possible for the same group of pupils to get, say, *three continuous years of science.* The general science movement has, thus far, as I see it, been a step backward rather than a step forward, because it has intensified the pellet science evil instead of eliminating it. It is acceptable to principals and superintendents because it is the easy thing from an administrative standpoint to have no continuous courses at all, and it seems to some of us that we have in recent years been doing for the most part in our school organization the easy thing instead of the pedagogically sound thing.

Let me say in just a word exactly what I want to see tried out somewhere in the United States. It aims at two things primarily, which I will call *continuity* and *time-exposure* in science; incidentally, it aims at what the general science advocates want, namely, an interlocking of the sciences so as to break down the water tight compartment evil, but it does it without wasting a year of time and substituting a smattering of science for real science.

I want to see a group of students who plan to take a full high school course begin in the second year a three year course in the fundamental sciences of physics, chemistry and biology. During these three years the pupil would get the equivalent of one unit of each of these sciences, but each of them would be

Digitized by Google

spread over three years of time. The group would use any good physics text, for example, and would meet for physics but twice a week for three years, or during one of those years it might have but one lesson in physics per week. A precisely similar plan would be followed in chemistry and biology. It is very easy to forget physics, but I think if for three years you keep the subject growing in a pupil's mind, it is going to sink in. Here is where we get our time-exposure in all three of the fundamental sciences. We get continuity through having the same group going more deeply each year into each of the sciences and solving progressively more difficult problems. We get finally the interlocking of the sciences which gives a unity to the whole.[2]

The advantages are obvious and the general plan has been in use in Europe for years. What are the disadvantages? The principal says, "Administratively difficult." I think he overestimates the difficulty, but surely we cannot sacrifice the whole purpose of education to administrative simplicity. Keep, if you want to, your pellet science for the flotsam and jetsam of your school population, for those who want to come to school for a year or two and then leave, but at least do not sacrifice the man who wants a sound and thorough high school course to the convenience of the misfits. Is not that what we have been doing to too large an extent in the past?

The war has demonstrated the value of science, it has waked up some of our leaders to its possibilities, and has emphasized the necessity for thoroughness in scientific training. It has opened up the possibility of doing something constructive in the education of our whole people to the appreciation and use of science. I have wanted to present very briefly the big need, as I see it, because there is now such an opportunity to get something done as has never existed before. It is up to us science teachers to see that something is done, but in my judgment nothing really big can be done inside of the walls of the present organization of courses.

[2]The details of this plan are somewhat more fully elaboratd in "The Elimination of Waste in the Teaching of Secondary School Science" SCHOOL SCIENCE and MATHEMATICS, Vol. XVI, March, 1916, p. 193.

MINING IN THE FAIRBANKS DISTRICT.

The Fairbanks district, in the Yukon basin, has produced over $70,000,000 in gold and has been a source of considerable silver, lead, tungsten, and antimony. The conditions in the district in 1917 are reported in a paper by Theodore Chapin that forms part of Bulletin 692-F. Mr. Chapin gives an account of the operations at the gold and the silver-lead lodes and at the tungsten deposits.

Digitized by Google

THE RELATION OF VOCATIONAL GUIDANCE TO OUR TEACHING OF SCIENCE AND MATHEMATICS.[1]

By ANNA Y. REED,

Assistant to Director General in Charge of Junior Work, United States Employment Service, Washington.

I am sure that all of us who have come here today have come with the idea of taking away with us something practical. Therefore, I shall say nothing on the theoretical side of the relation of vocational guidance to the teaching of science and mathematics, but shall proceed at once to the practical side of the matter.

Our department handles the placement work of all boys and girls up to twenty-one years of age, covering the high schools and to some extent the colleges. Quite recently I was in a Junior High School where the arithmetic lesson for the day was on the parcel post system. The teacher was not very much interested, neither were the children. They were using that arithmetic which is quite common in our schools today, the Walsh Arithmetic," and the more questions the teacher asked, the more it became evident that the period was going to be wasted. Seeing this, I felt justified in speaking to the children. I told a story to the boys and girls, and when I had finished, you could have heard a pin drop in the room. Gradually the children began to open their arithmetics and to ask questions. One boy asked if the lesson could be had over again the next day. The trouble was that there was no relation in the teacher's mind between that parcel post lesson and the use that lesson could be put to in outside life. I have had many boys lose good positions in the business world because they did not know the parcel post system, and when you come before a group of boys and girls and tell them this, you will get their attention. I have known of one boy after another who, because he could not master the zone system, lost his position. The employers say this: "We don't expect the boys to know the system when they come to us, but we do expect them to have enough fundamental knowledge to master the work in a few days, and we have these maps on the wall for them to use, but they don't do the work correctly and we discharge them." When I told the boys and girls about the loss of these good positions, they wanted to know something about the parcel post system, and those two or three

[1]Delivered before the General Meeting of the Central Association of Science and Mathematics Teachers at the Lake View High School, Chicago, November 28, 1919.

Digitized by Google

pages of seemingly unimportant material in their arithmetics suddenly became very important. Now the relation between the parcel post system and the teaching of that lesson had been the difficulty.

Again, we send our girls out into the factories. The girls who pass through your training schools and home economics departments go out into machine operated factories to handle the making of garments. They will work a week or perhaps two and then come back to me and say, "I don't think I am getting a fair wage. Emma gets $18.00 a week for making buttonholes and I only get $9.00."

"What makes you think that your wage isn't right?"

"Why she made 3,500 buttonholes, but I made 2,000, and I think I should have a little more than half the pay she gets."

A girl of that type has no conception of the way a business man handles the mathematics of his business. She doesn't know what the word "overhead" means. Then I say to her, "Do you know how many buttonholes that machine can make under a skilled operator, that on days it is well handled it can turn out 4,000 buttonholes? Well, the girl who makes 3,500 buttonholes a day is a good investment from the point of view of the employer, because the overhead is covered. The fact that you make 2,000 buttonholes while she makes 3,500 has nothing to do with it. Your employer is wasting space by keeping you in his shop. In short, you are an expensive girl to employ at any cost. Instead of getting cheap labor, as you think he is getting, he is getting expensive labor."

In most of our arithmetic problems today there is no calculation in overhead, and our boys and girls should know these practical things. As a matter of fact, a girl who can make but 2,000 buttonholes a day is not wanted. Our girls do not know this, and they come back disappointed, because they have not been taught the relation between using their labor and the cost of it.

A teacher came into one of our offices four or five weeks ago in one of the large cities, and said to me that she had a very bright boy in one of her classes who had to drop out of school although he was only just ready for the eighth grade. She said he wanted to take up radio operating, and that she had advised him to put $100 into a course. She had tried to get him a scholarship, but was unable to do so, and the boy had made arrangements to pay for the course on the installment

Digitized by Google

plan. She asked if our office would take an interest in him. But it was too late to take an interest in him when the harm had already been done. I said to the teacher, "What do you know about the opportunities for radio operating today? Do you know anything about radio work? Don't you see that if you advise that boy to take up radio operating, having only been through the seventh grade, that you will handicap him from doing other things in the future?" She had no idea of the difference between ordinary radio operating and the higher lines of that work that an experienced and well educated man may handle. She was sending a young boy into a certain type of blind alley work. When I began to talk to her about the mathematics the boy needed and the limitations of a seventh grade education, she was not so confident. I said to her, "You should have given this boy all the information available on radio work and on the requirements in sciences before you let him put $100 into that course. Did you consult anyone about it?"

"Oh, yes, I went to the radio school, and they said that the boy didn't need any more education than he had."

"Don't you see," I answered, "that it was to the advantage of the radio school to say that? They had no personal interest in the boy. All they wanted was the $100 for the course."

In that teacher's mind there was no relation between vocational guidance and the teaching of mathematics and science. She thought she was giving this boy first class advice. When is the time coming when teachers will be able to handle these problems?

A boy came into one of our offices recently, and said to me, "Mrs. Reed, I am afraid I am not going to like that position."

"Why?"

"Well, I went in with the understanding that I was to be employed seven and a half hours a day, and I have only worked one day and they kept me half an hour overtime."

"What were you doing?"

"I was in the shop. The manager was going over some details of the work with me."

"How much work did you do?"

"Oh, I didn't do anything very much. The owner of the plant was there too, and he and the manager were talking and sort of outlining the work for me."

"These men stayed half an hour overtime, too?"

"Yes."

Digitized by Google

"They were explaining the work to you and showing you how it could best be done?"

"Yes."

"When you took that position you took it at the same salary of the man who had the position previously and who knew all about the work. Has it occurred to you, young man, that the people who were working overtime were the owner and the manager?"

He hadn't thought of that. Yet the boy had been through a good high school. He thought that every minute he was in that plant overtime was to the advantage of someone else. He did not know that every time a man is taken in at a salary the same as the person who left received, he is being paid for something he does not earn until he fully understands the work. I said to the boy in question, "Go back and you may amount to something a little later in life." He was a rather old boy to just learn the practical side of work.

Again, we had a boy who went through the eighth grade. He is now twenty-five years of age. During the war the opportunity for great progress came to him, but he was handicapped for life because he did not have the related subjects to put himself ahead. When I first knew him he was working in a chemist's shop. I asked the owners if they would also take a young college boy into this same shop. They said, "We don't need him. It is the dull season. All we could offer him would be an office boy job at $30 a month. An uneducated boy would do just as well." I asked the college boy if he wanted the office boy job. He said he would take it, that he was anxious to know just what were the duties of an office boy in a chemist's shop at $30 a month. At this time the boy I spoke of first was earning $75 a month, which was then a very fair salary. The two boys worked together. The college boy swept the office, and afterwards went out soliciting orders. Then he went down into the plant to do odd jobs. When he saw the $75 a month boy sitting on a stool waiting for a repair man to come to fix one of the machines, he said, "What is the use of our wasting our time? Why not fix the machine ourselves?"

"Oh, no, we always send for a repair man."

The college boy, however, went to work and with the knowledge he had acquired in shop work at college he repaired the machine. Before long he became familiar with one or two other lines of work. When the firm received a large order for

Digitized by Google

creosoting they found that none of their men knew anything about this line or work. The president called the young college boy to him and said, "I am greatly surprised to see how many lines of related work you are familiar with. I wonder if you could prepare yourself sufficiently in two weeks' time to enable us to take this creosoting order? Can you handle the work?" The college boy said he could, and he went nights to his college library and read all the available information on this subject. His firm took the contract for the work and it was done successfully. His salary was raised to $100 a month. The $75 a month boy was still getting $75 a month. Soon after, this $75 a month boy came to me and said, "My firm wants me to do some work in which I have to compute a square. I don't know whether this requires algebra or geometry." This boy could not get ahead because he knew nothing of the related subjects required in the work he had chosen. None of his teachers had told him that that there was a limit to what he could do in chemistry if he didn't have the related work. When the war came the college boy went right to the top with a high salaried civilian position, while the other boy went into the draft, handicapped for life.

Our employment offices are full of reports that show that there is no relation between the subjects of mathematics and science and their use in after life. I am telling you these stories not just to interest you, but because I feel that they will cause you to modify your curriculum so that it will be more practical, so that the avenues of education will be broader. At the present time your teaching of science and mathematics is not being done under the most favorable conditions, because you do not know the facts of industrial work as well as you should know them. I don't see how a man or woman can be in a school building all day and know very much about industrial work, but I blame you because you do not demand that there be a source for ascertaining information that will help you to tell your boys and girls what they need. Fifty per cent of the failures of the boys and girls who come from our public schools are due to things that could have been remedied. This is a general statement, of course, but I have kept as careful a record as I could of the failures of boys and girls, and as nearly as I can estimate, fifty per cent of these failures are due to conditions which could just as well have been remedied had the public schools done their share. Seventy per cent of the turnover of our young people is absolutely useless, and fifty per cent due to the fact that there is no relation between

Digitized by Google

vocational guidance and the work done in our schools. Isn't this one fact enough to make us realize that this is an important thing? And yet we have been fooling with vocational guidance for fifteen years, without founding practical avenues wherein to obtain practical information. I don't think it makes any difference what I may know that would be of value if you do not take that knowledge and put it into your schools. The responsibility lies first on the educator to know the facts of industry and thereby help the boys and girls to choose the right subjects in school. After this comes the work of vocational guidance for vocational educational purposes, and finally comes the work of the employment service which is to take the product of our public schools and so help them to use their talents that they may be best placed. The next step is the returns on placements which come back to us. We hear this, "I think that if the public schools had done their work better we would not have had so many failures." Then the business houses securely file away all the information they have on the subject. It doesn't occur to them that this information belongs to us. If we are to be successful in placing our boys and girls in the business world we must have the cooperation of everyone concerned. We cannot do this work alone.

During the war there were many young women who wanted positions as chemists. We couldn't place them because they didn't have physics. Many firms wanted a combination of chemistry and bacteriology, which these girls did not have.

Recently women have gone into engineering, but they have not been successful. Upon inquiry employers tell me that these women will not be kept permanently, for, although they can do drafting, they can do no layout work. Yet I find many advisers for women in our colleges who say off hand that there is plenty of opportunity for women in engineering. The women who have gone into this work are not going to reach the top. They are going to keep the lower positions, because women have not made good in this branch of industry. When our girls come to us and say, "I was offered $80 while a man was offered $120 and I believe in equal pay for equal work," we can be sure that there isn't any equal work about it. In engineering, women are not hired to do the same kind of work that men do. A firm will not take a man in at $120 unless it feels that he soon will be worth more. Firms do not feel this way about women. Here

Digitized by Google

and there, of course, women have made good in this line, but that is exceptional. Women are still regarded as business risks in engineering.

I think that we should have some scheme whereby our boys and girls may test the various occupations in a general way. There are many simple tests that can be taken into the high schools that will enable the boys and girls to discuss each industry and see what there is in each industry for them. I took up a test of this kind the other day at the Normal School. The principal was very anxious to have his teachers get some practical methods. I said I would take all the Junior High School students and that I would try to give a model lesson. I asked each boy and girl to keep in mind some definite occupation that they would like to take up when they grow older. There were more boys who chose science than there were who chose anything else. When the question of skilled, semi-skilled and unskilled labor came up, it was marvelous to see how these boys grasped the idea that it was their previous preparation which determined into which group of labor they would go. One boy came to me afterward and said that he had intended to leave school at the end of that term, but that he was afraid now if he did so he would get into the unskilled class. With these tests we can give your boys and girls a good general background.

The average teacher does not know enough about industrial work to advise the pupils. We must have men and women who are paid just for concentrating on this subject, and who will come back to you to answer questions that will help you. I hope that we shall soon be able to combine this work with education, so that it will mean much to educators of our country. I hope that the educators will soon realize that fifty per cent of this work is their responsibility. The question is often asked, "Does this work belong to the Department of Labor or to the Department of Education?" I don't know. I don't think it makes any difference, but unless fifty per cent of the responsibility is taken by educators it is going to be a failure. Are you prepared and are you willing to lead in this matter of vocational guidance and placement? We have been fooling, as has been said, for fifteen years without accomplishing much. As an example, in one of our large cities I recently heard the boast that there had been 1,800 boys and girls placed in positions within one year. I said, "Do you realize that if you met the requirements of your city that you would have placed 18,000?"

Digitized by Google

Vocational guidance and placement means the opening of a new avenue in education. If we have an employment service in Chicago, it will mean that when we send word to you that over here is a business house which is going to discharge a boy because he can't read blue prints, and in another place are several boys who can't be promoted because they are unable to read blue prints, it will mean that you will have to take these boys and say "You will be able to read blue prints before we get through with you." Unless you do this, you will be missing one of the greatest opportunities in education today. Again we may send you word that there are fifteen girls who are failing as stenographers because they are not speedy enough. It is your business to take these girls and place them under a special teacher who will drill them on speed alone until they come up to the standard. This work is fifty per cent education and fifty per cent employment. It is the type of work that will do more for the business houses and more for our boys and girls than any other thing. It will do away with much of our present labor unrest and the feeling among our young people, when they have drifted about for several unprofitable years, that the world owes them a living.

WATER SUPPLY FOR SAN DIEGO, CALIFORNIA.

Practical Problems of a Romantic Playground.

One of the popular playgrounds of the United States lies around San Diego, Calif., in the extreme southwest corner of the country. The mild, healthful climate, the beautiful scenery, and the romantic historical associations of this out-of-the-way yet readily accessible region give it a peculiar fascination that is attracting to it from year to year an ever-increasing number of tourists and permanent inhabitants. Here a narrow belt of lowland and "mesa" is bathed on one side by the Pacific Ocean and bordered on the other by a mountainous highland from the summits of which magnificent views stretch to the Pacific on the west and to the Salton Sea and the Colorado Desert on the east. Excellent automobile roads lead from the seashore to the mountain crests and connect all parts of the region with Los Angeles. Travelers along these roads can see the old Spanish missions, the ruins of primitive irrigation systems built long ago by Franciscan monks, numerous quaint old places, and humble villages inhabited by Indians.

San Diego is not only the center of a fascinating national playground but the center of a rapidly increasing commerce. Its excellent harbor is the first one in the United States to be reached by west-bound ships coming through the Panama Canal, and a new railroad, now practically completed, connects it directly with the thriving agricultural districts of Imperial Valley and Arizona.

The resource that is most essential to the development of this district is water. Nowhere else in the United States is water more valuable than in the vicinity of San Diego, and perhaps nowhere else have more resolute efforts been made to conserve and utilize it.

Digitized by Google

AN OLD FORM OF TOP REVIVED.

By Chas. T. Knipp,
University of Illinois, Urbana, Ill.

The top described in this article was made in Ohio over forty years ago by a country-side cabinet-maker. It appears that this form has neither been described in any of our scientific journals nor mentioned in books descriptive of tops and gyroscopic motion. Its spinning qualities warrant giving it a brief description here.

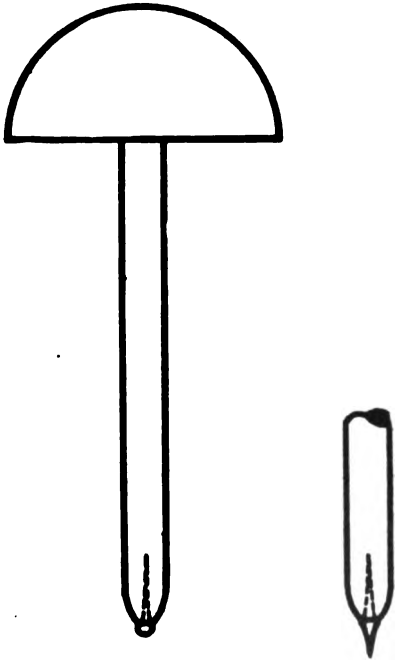


Fig. 1.

The top proper is illustrated in Fig. 1, which is full size. It should be turned out of tough wood, preferably maple. A smooth round headed tack is driven into the foot of the leg, as shown in the figure. A second top with a sharp tip should also be provided.

To spin either, a strong slender string and a special holder are necessary. The latter may well be a piece of poplar wood having dimensions of about ¾x1½x5½ inches. Through one end of this holder a half inch hole is bored, while the other is partially turned down for a handle. The top with the string wound on its leg, inserted in holder ready for spinning, is shown

Digitized by Google

in Fig. 2. The string should be wound solidly on the leg (single layer) from the tip up to the head. To prevent the top from slipping bodily out of holder before it is completely spun, and to insure maximum speed, the holder must be tilted slightly away from the line of draft of string. These points are shown in Fig. 2.

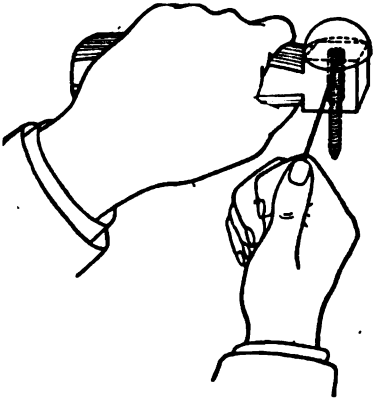


FIG. 2.

With the holder firmly gripped by the left hand, spin the top by pulling steadily and quickly on the string with the right hand. The string as it unwinds will lift the top out of the holder, the top dropping to the floor, spinning most beautifully. After several trials the operator will feel safe in imparting greater and greater speed to his top, fairly making it hum.

Aside from being a toy, this form of top may be used in illustrating the principles of gyroscopic motion. Possibly the most striking example is to note how quickly the spinning top will "go to sleep." For this purpose use the one with a smooth round tip. When spun, the axis quite likely, when the top strikes the floor, will be inclined at an angle to the vertical. The top will at once begin to precess (swing around) about this vertical, and will almost immediately erect itself and spin on quietly. It does not matter at what speed the top with a round tip is spun, it always erects itself, and at the end of the run it will "die" very quickly.

The counterpart of the above experiment is to spin the top having the sharp tip. Again, as it drops to the floor (or table) its axis will, in general, make an angle to the vertical. It will be noted that though the axis in this case precesses as before, it now remains at *constant* angle to the vertical throughout the time of vigorous spinning,—the top will not erect itself, and, at the end of the run, will die slowly.

Digitized by Google

The explanation of the behavior in the two cases just enumerated is found in books on gyroscopic motion.[1] Briefly, in the case of the round tip there is rolling motion on the floor which causes a component being formed that tends to tilt the axis towards the vertical. In the case of the pointed tip there is little or no rolling motion, hence the vertical component is lacking, and the top does not rise.

Another interesting point that may be illustrated is, that the axis of the spinning top tends to remain parallel to itself while spinning in mid air. Spin the top (having the round tip) vigorously, so that when it leaves the holder its axis makes an angle of, say, 45° to the vertical. If the speed is great, the top will bounce about like a rubber ball, the axis all the while remaining parallel to itself. However, as soon as the top settles down on the floor, it begins to precess, rolling friction comes into play and the top erects itself.

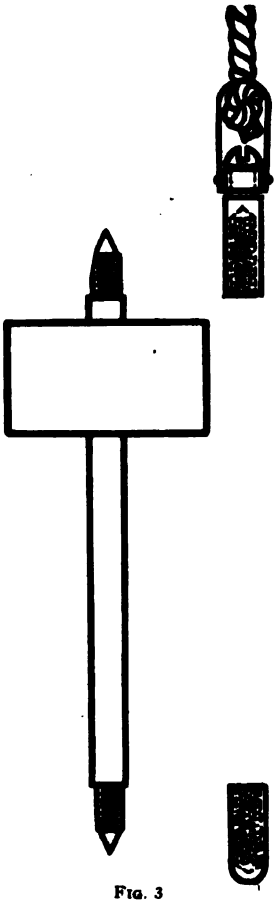


FIG. 3

It should also be noted that the top with the sharp tip may not remain "put" in case the floor is very smooth, but persists in precessing about its center of gyration, i. e., the leg sweeping in a wide circle about the vertical axis.

For a more extended study of the effects of round and sharp tips, as well as the effect of transferring the point of support, metal tops, such as sketched in Figs. 3 and 4, may be used to advantage. A metal top with its interchangeable tips and swivel support is shown in Fig. 3, which is drawn full size. The body is made of brass and the stem of twist drill steel rod. The stem extends through the head of the top and has a sharp tip at either end. These tips should be case-hardened. A steel cap with a round tip may be, in turn, screwed on either end, thus converting the top from sharp to round tips and vice versa.

[1] *Spinning Tops*, John Perry, London. *Spinning Tops and Gyroscopic Motion*, Harold Crabtree, Longmans, Green and Co., New York.

Digitized by Google

The holder for spinning is the same as that used in Fig. 2. The metal top, because of its greater momentum, spins correspondingly longer. When spun on the short leg with the round tip on a smooth (waxed) floor it will go to sleep with ease for five minutes. To spin on its short leg it is only necessary to turn the top upside down in the holder, tilt the axis *towards* the operator, and pull on the string steadily and quickly.

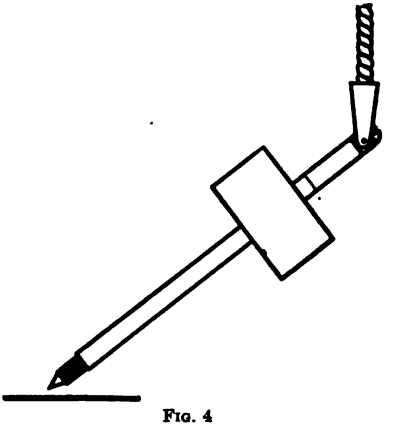


FIG. 4

Lastly, a most interesting experiment, showing the dependence of the direction of the precessional motion upon the manner of support of the spinning top, may be performed by providing a swivel joint to be screwed on the short leg, the construction of which is shown in Fig. 3. By reference to Fig. 2 it will be seen that, with the string wound as shown, the top when spun turns in the clockwise direction, looking down from above. Its precessional motion when spinning on the floor will also be in the clockwise direction. If now the top be supported by the swivel with a rather heavy cord attached (to prevent winding up), and again spun in the clockwise direction, it will precess in the *counter clockwise* direction, and if lowered so that the tip rests on the floor (Fig. 4) the precessional motion at once becomes *clockwise*. On lifting it off the floor it again becomes *counter clockwise*. This experiment works best with the pointed tip, the round tip causing the top to erect itself so quickly that the precessional motion is lost to view. Of course, if the top is spun in the reverse direction, the precessional motion in each case will be reversed.

Other uses to which this form of top may be put will suggest themselves to the operator.

Digitized by Google

WHAT CHANGES SHOULD BE MADE IN OUR METHODS OF TEACHING HIGH SCHOOL GEOGRAPHY?[1]

By W. R. McConnell,
Miami University, Oxford, Ohio.

Fifty years ago there were but forty public high schools in the United States; today there are over twelve thousand. Along with this tremendous increase in public high schools during the last half century has gone a very much changed conception of the function for which the high school exists. It has not been long ago that public high schools were attended chiefly by those who were on their road to college. The high school was thought of as being one of the stages through which those and only those travelling toward college need pass. But now hundreds of thousands of young people, who have no prospect whatsoever of continuing in higher education crowd the classrooms of our public high schools. I believe that the proportion of those who complete the high school and later graduate from college is about one out of eight. The American high school has become in reality the university where all the children of all the people may attend and from it receive whatever it has to give them. From it they go with as broad an outlook upon life as it has opened up to them.

Now it is quite obvious that this great enthusiasm for secondary education in America, backed as it is by public opinion throughout the land should attract the attention of our ablest educators and challenge them to thoughtfully consider the aims and purposes of high school instruction. How may the high school best serve the interests of the hosts of young people who are today attending it?

There is today among those who have at heart the shaping of educational thought in this country a rather general agreement as to the fundamental aims of secondary education. Briefly stated it is that the student should undergo those experiences in the high schools that will tend to make them good citizens. To train for citizenship is the primary purpose of secondary school instruction. "Citizenship" is thought of in terms of socially useful ends. Boys and girls are to be prepared for personal usefulness in a modern world. As life in our modern democracy becomes more complex there is a constantly increasing need for a greater amount of common knowledge which the elementary school is inadequate to give because of the age of

[1]Read before the Geography Section of the C. A. S. and M. T., Lake View High School, Chicago, November 28, 1919.

Digitized by Google

the pupils. It is during the high school age that young people can put away childish things and intelligently appreciate the interests and activities of men and women and by assisting and stimulating boys and girls to take an intelligent and helpful interest in the performance of duties and responsibilities that will come to them in their lives as future citizens the public high school may become the greatest quickening and unifying force in American life.

Once the aims of high school education are established it, of course, follows that attempts will be made to fashion a curriculum that will get results. If the high school is to make good citizens then the curriculum must give such training as will assist in the performance of duties as future citizens.

It is quite obvious that those who agree upon a fundamental aim of high school instruction will differ greatly in their opinions as to what should be the specific experiences that will make for good citizenship. The high school curriculum must and should for a long time to come be in the making. The subjects of study and the methods of presenting the material must ever be uppermost in the minds of those who are charged with the special mission of fashioning its curriculum so as to make it an agent of the greatest usefulness.

If geography is to have a place in the high school curriculum it should be there because in its study boys and girls go through experiences that will make them better citizens. If geography or any other study is to remain in the high school curriculum it must do so because it is justified from the standpoint of educational aims. Then and not until then will geography be ready to play the part which it should have in the training of the young people of America. The geographer and the educator must come to know each other a great deal better in the future than they have in the past. It is our educational leaders who formulate the aims of education and in a large measure shape the curriculum rather than one interested in any special subject of study.

Twenty-six years ago a committee was appointed by the National Educational Association to reorganize the high school curriculum. Among other things in its report this committee recommended a year of physical geography as an introductory science course in the high school and in their argument for it stated that it offered special opportunity for training the powers

Digitized by Google

of observation, the scientific imagination and the ability to reason.

I do not care to go into a lengthy discussion of educational theory but it behooves every teacher of geography at this time to earnestly inquire why it is that geography is not in the high schools today to any thing like the extent that it should be despite the report of this able committee. Some may argue that it failed because of inadequately trained teachers, but I am inclined to think that its place in the high school curriculum was questioned because the argument of the committee for its being there has been found to be based upon unsound educational doctrine. It was based upon a belief in the so-called "doctrine of formal discipline" or the transfer of training—a belief that training in observation or reasoning in one subject of study will carry over into and function in all other fields of knowledge or action.

Since this report in 1893 educational theory and practice has gone on a long journey and along its pathway lie many discarded notions among the rubbish of which may be found the whitening bones of the doctrine of formal discipline when it is thought of in the sense that the "committee of ten" were without doubt thinking.

Another report of a committee on secondary education in 1909, realizing that pure physical geography could no longer be defended, recommended "that about one half year be devoted to the larger topics in physical geography with the human side made more prominent than at present and that the remainder of the year be given to a study of North America and Europe." Since this report in 1909 the geography work in high schools has drifted. It has seemed to lack unity or purpose, and in many schools it was dropped from the curriculum and general science has occupied the place once designated for geography.

Geography has failed to secure a more prominent place in the secondary school curriculum because it has not responded to educational demands. Its content and above all, its method of presentation has changed but little during the last decade. Students are still memorizing facts and principles isolated from all significance and from all relationship, and where laboratory work is offered in the subject it has, in too many cases, become a mere liturgy.

Other subjects of study have responded to new occasions and new duties. There is, for example, today, a new history, a

Digitized by Google

history in which the human activities of the past are portrayed against a background of geographic conditions. One of the most used texts in the high school history classes of today is to a considerable degree a text in applied human geography. One who has the interests of geography at heart and who is aware of its possibilities and of the pressing need of more geographical knowledge cannot read a modern high school history without feeling that geographers are sinning away their day of grace.

In the history text to which I referred one finds a discussion of such subjects as the "Woolen Industry," "The Iron Industry," "Transportation," the "Conservation of Natural Resources," and many other similar topics. I am not saying that these topics should not be in a history text book. They are just the things that should be taught to American boys and girls of high school age and I am glad that they are taught in some degree at least, in some connection. But whatever historical aspect these subjects may have must be closely interwoven with basic geographic considerations which must be taken into account in any historical treatment of them. If these subjects had been adequately taken care of in the high school geography class they would not now receive such extensive treatment in our history text books and what historical bearings they have would be much more intelligently interpreted. Such geography as is now found in these historical texts would receive the sanction of educators. There would be no struggle for its existence in the curriculum. We would all understand that there was no conflict between geography and general science but rather that general science was an aid to the study of geography just as it is an aid to chemistry and physics and other science courses that come in the later years of the high school course.

In the history text to which I have referred there are maps of the cotton belt, our coal and iron ore deposits, the distributions of manufacturing, and the forest regions of United States. There are more and better railroad maps and transportation maps of the world than are found in most of our modern texts in geography. In the questions and exercises at the close of the chapters one finds such as: "What conditions in Europe combined with the geography of the regions settled in America tended to make the French and English colonies in America quite different?" "Why was the site of Pittsburgh an important point in the struggle of France and England for supremacy in America?" "Why were the northern colonies more actively

Digitized by Google

engaged in shipbuilding than the southern colonies?" "Why did Pennsylvania become the center of the iron industry?"

Thus while those interested in geography have been talking and vacillating and spending years in pusillanimous delay in debating general science versus geography in the high school curriculum there has grown up a new history which understands and appreciates the influence of geographic environment on the life and activities of people. But certainly no intelligent writer of history would assume that high school pupils are in possession of enough geographical knowledge of any particular region to correctly interpret the history of that region. In working out any one of the exercises mentioned above, as for example, "Why did Pennsylvania become the center of the iron industry?" the teacher of history would find it necessary to thoroughly teach the geography of Pennsylvania and its environments and to read the answer to the exercise in the light of that geographical knowledge. But should the teacher of history teach the geographic background of such an exercise or should the geography teacher do it? Why should not the geography teacher teach the history that is written on a geographic background? Why should not the teacher of high school geography also handle the history work done in the high school, particularly the courses in industrial history?

Geography teachers have long talked about a "human geography," but, I suppose, having so recently inherited our ideas from the school that just preceded this generation, it is but natural that we should revert to the type and feel that we are not teaching geography unless we are drilling our pupils on some phase of physical geography. A very common method of deluding ourselves into a belief that we are teaching applied geography at the present time is to drill on geographic factors or principles or "controls" and then go over the world conjuring into existence conditions, some real and some imaginary, in which the factors or principles or controls are seen in action among people and then wonder why educators should not see why geography should be in the curriculum of the high school. What we have overlooked is that the factors and principles may be taught by beginning with human activities and interpreting them in the light of adjustment to geographic environment. We have dealt with such topics as "Mountains in their Relation to Human Life" rather than "Life in Eastern United States as Influenced by the Appalachian Mountain System." We have

Digitized by Google

taught "Plateaus and Plains and their Relations to Life" rather than to contrast life on the Atlantic coastal plains with life on the Piedmont region. We study the influence of mountain passes rather than "American History as Influenced by the Hudson-Mohawk Gap." We study the "Climatic Influences of Lakes" rather than "The Fruit Industry of Western New York or Michigan." We have been content with giving isolated examples of geographic influences in various regions rather than to study in detail the life of any particular region and interpret it in its relation to geographic environment.

Geography straddles two sciences. It is the link between the social and the natural sciences. On the side of content it belongs in a group with history, civics, political science, sociology, and commercial and industrial education. All of these subjects aim at adjusting man to his environment, and unquestionably such studies are destined to occupy a space of ever-widening dimensions in the high school curriculum. Such studies supply the basis for sympathetic social cooperation.

Regardless of where geography may get its data, its basic point of view is social. Sympathy and genuine interest in other people which leads to cooperation with them has its foundation in a knowledge of their general surroundings and activities. Our degree of interest in other people is almost directly proportionate to our knowledge of them, how they are living, what they are doing, what economic and social problems confront them, and how they are equipped to handle these. During the war we found it necessary to enter into sympathetic cooperation with other people living in a different environment than our own and one of the chief effects of the war upon geography was to enhance interest in it. Teachers of geography can ask themselves no more important question than "Shall that interest continue?" Surely it was demonstrated that a knowledge of geography is necessary if one is to keep in touch with the large and influential elements of modern life. Geographic ignorance today means that one is living as a stranger in a strange land. This is not because he has failed to memorize a certain number of facts or principles but because he cannot intelligently interpret the activities of various groups of people.

The field of geography is the social, political and business life of the world. The controlling aim in teaching it should be to know people, to understand people and to appreciate people not as individuals but as groups occupying the various nations of the world.

Digitized by Google

The teacher of high school geography, realizing that his aim is to teach the pupil to use his mind in working out problems in the fields of knowledge that will confront him as a citizen, should ask himself: "What are the problems which the everyday man is likely to meet that will have to be solved through a knowledge of geography?" Physics is no longer taught for the purpose of training the mind. We teach it for its practical value and trust that in the process of solving practical problems where a knowledge of physics is needed the mind will be trained in a method of attacking all problems of a similar nature. In the same way and for the same ends should we teach geography. The kind of geography needed is that which will aid in a solution of problems arising in connection with such things as industrial legislation, banking and finance, supply and demand, reciprocity, free trade and protection, and practically all current international questions, a knowledge of which is fundamental for intelligent and responsible citizenship. It is the business and the privilege of the high school teacher to teach the geographic factors involved in situations arising from such vital issues. The problem of Japanese expansion, the Irish question, Polish agitation for Upper Silesia and Lloyd George's boast that the Allies have annexed six hundred thousand square miles of German territory are concrete examples of topics suited for the modern high school geography class.

The kind of geography that should be taught in the secondary school, then, should be neither physical geography nor commercial geography but it should be applied regional geography, a study of the geographic factors that enter into the historical, economic and social life of the people of the various countries of the world. As Dewey, in his book *Education and Democracy*, has pointed out, separate phases of geographical study are not to be adjusted by an external compromise that crowds so much material into each of them, but it must be constantly borne in mind that the educational center of gravity is in the human aspects of the subject. "From this center," says Dewey, "any material becomes relevant in so far as it is needed to help appreciate the significance of human activities and relations." Thus has one of our greatest educators set up a working definition of geography, perhaps the best that is found in modern literature.

I have said that our high school geography should be regional. The region need not be a physiographic province, and it certainly should not be a continent as a whole. It may well be a

Digitized by Google

section having similar trade and industrial interests, as for example "Eastern Canada" or "The Mediterranean Lands," or it may well be a nation. There is much argument in favor of taking the nations as units for study. It is imperative in these days that we should know humanity as divided into nations, what a nation is, how many nations there are on earth and their distribution. It is important that we know in so far as possible the character of each of these nations: its customs, its interests, its weaknesses and its strength, its international relations and what hopes and fears it justifies. These are the things that a good citizen should know and the high school geography class should contribute its share (and it should be a large share) toward giving this information. If, for example, we are to live peacefully with Mexico it will be necessary for us to visualize the Mexican people and know how the Mexicans are living, the kind of environment they have to work with and the future possibilities of such an environment.

We should do more with the problem method of teaching than has been done in the past. Its use is a movement in education of great significance. Educators are favoring a wise use of the problem because it leads to the selection and disentanglement of primal factors in a situation and aids the teacher in bringing into the focus of conscious attention basal facts and principles which would otherwise be lost in a mass of irrelevant detail. Our text books will be properly used when the material in them is made use of in the solution of some vital problems.

If those who have the opportunity of teaching high school geography will teach applied regional geography and make free use of carefully thought out problems in presenting their lessons it will go a long ways toward securing for geography the place that it should occupy in the modern high school curriculum.

ALASKA PRODUCES TIN.

The tin mines of Alaska produced 136,000 pounds of tin, valued at $118,000, in 1918, according to the U. S. Geological Survey, Department of the Interior. These figures may be compared with 200,000 pounds, valued at $123,300, in 1917. The decrease in output in 1918 was due to the fact that only one dredge was operated. Additional tin, however, was recovered by sluicing. The first important production of Alaska tin was reported in 1902, when the output was 15 tons. Since 1912 the average has been over 100 tons annually.

The recent discovery of placer tin has been reported from Potato and Humboldt creeks, on Seward Peninsula, and from Moran Creek, a tributary of Melozi River, where the gravels are said to contain 2½ pounds of tin and 10 cents' worth of gold to the cubic yard.

Digitized by Google

CORRELATION OF MATHEMATICAL SUBJECTS.

By E. R. BRESLICH,

The School of Education, The University of Chicago.

In the traditional high-school courses the various subjects of mathematics are taught separately. Algebra is usually taught in the first year, plane geometry in the second, and advanced algebra in the third. These are followed by courses in trigonometry or solid geometry. Leading mathematicians and professors of the teaching of mathematics in England, Continental Europe and in America have long recognized the relationship between the subjects of secondary mathematics, especially algebra and geometry, and have advocated with emphatic presentation of detailed reason the desirability of teaching them together. Teachers have also felt that better results could be accomplished with the high-school pupil by correlating these subjects. However, this movement for correlation has been insistently opposed by those who fear that it may ultimately result in a complete "fusion" which in turn may lead to "confusion" on the part of the pupil, and by the owners of traditional textbooks.

In making important changes in a traditional subject such as mathematics, historical considerations are not to be disregarded. Particularly, one should study the question whether the present high-school courses in mathematics are the outcome of a broad, well-conceived plan so organized as to accomplish the aims and purposes of present secondary education. We find that among the subjects studied by the ancient nations geometry became early a highly developed science. The speculative mind of the Greek, disregarding the practical phase of Egyptian geometry, changed the study of geometry into the form of a liberal education. At the time of Pythagoras it was a flourishing science. Later it was transferred to Egypt, the land of its origin, where Euclid gave to the world his book on geometry, called the *Elements*. In this he formulated a system of geometry which to the present time has practically remained the same. Its main purpose was not to give training in space relations, but to serve as a study for the adult mind. It continued to be studied because of its logical form, which was supposed to be perfect, and because of its supposedly great value as a means of training the mind. Being an advanced subject it was transferred to the upper classes when taken into the high school. Hence we find in our modern educational system little or no instruction in space relations until

Digitized by Google

the pupil reaches the second year of the high school, or until he enters a course in solid geometry. Since the proportion of pupils reaching these courses is relatively small, the large mass of children get very little experience with space relations in their school work, unless they pick it up outside of their courses in mathematics.

The Greeks, who contributed so much to the development of geometry, did very little for arithmetic and algebra. Their system of notation was very clumsy, making operations in arithmetic exceedingly difficult. Toward the close of the twelfth century, however, the arithmetical and algebraic knowledge of the Arabs was brought to Italy. Because of its good notation, which is essential for proficient work in numbers, it was readily accepted. Through Rome it passed into the curriculum of mediaeval Europe. Spreading rapidly, at the end of the thirteenth century Arabic arithmetic had been fairly introduced into Germany, France and England. Since algebra had its origin in arithmetic it flourished with the development of the science of arithmetic, and since arithmetic took a low place on the curriculum, algebra, with its exceedingly difficult abstractions, also took a position lower than geometry.

Evidently the fact that algebra precedes demonstrative geometry in our high-school courses is not part of a carefully considered plan. It is a historical accident and in spite of the fact that a large percentage of pupils fail to master it, algebra still retains its position.

Some schools, feeling the need of giving the pupil training in space relations before he takes up the study of algebra, have tried to find a remedy by teaching the two subjects in the reverse order. This plan has not been successful. For, in both courses many pupils lose their hold early and after that profit little by further instruction. Either plan overlooks the facts that algebra and demonstrative geometry both involve abstractions which are exceedingly difficult for the pupil of the early high-school period, unless a wide experience with the fundamental concepts precedes, and that they contain simple and difficult facts which should be so arranged that as far as possible the simple fact be taught first. Such a psychological arrangement leads to a breaking up of the historical lines of division and to a correlation of the two subjects.

Another effort to get a psychological arrangement is the plan of teaching each subject on certain days of each week. Algebra

Digitized by Google

is taught two or three days and geometry for the remainder of the week. This plan has not been popular among teachers and pupils. For, the pupil has to carry two textbooks and is continually confused as to the lesson assignments. The abrupt change from one subject, at a time when everybody seems to be interested, to the other, jars both teachers and pupils. The plan is not economical as to time because an interruption of several days during the study of a topic makes a review necessary when it is again taken up. The solution of the difficulty lies in a systematic arrangement of the two subjects in a single textbook.

There is much to be said in favor of this plan and some of the advantages are enumerated in the following.

It facilitates a psychological arrangement of the subject matter. Each of the various divisions of secondary mathematics—arithmetic, algebra, geometry, and trigonometry—includes simple principles relatively easy to master, and also difficult, complex principles. The simple principles are best suited to beginners, and may therefore be brought together in a course which gradually leads up to the more complex aspects of these various branches of mathematical science. Each subject is reinforced by the aid of the others, and the entire work is unified and vitalized. For example, algebra and geometry supplement each other. Both are used to express facts about quantity. The formula and the graph are only different ways of expressing the law of a group of numerical facts. Each states the facts in generalized form and thus makes possible the deduction of any number of particular cases. Moreover, when the two forms of thought are correlated in a single course of instruction the student's comprehension of quantity is at the same time deepened and simplified, deepened because of the more enduring impression made upon the mind, and simplified because the double method of attack makes it easier to overcome difficulties by supplying always a strategic alternative.

It reduces formalism. When the various mathematical subjects are treated separately, each tends to take on the rigid form of the final science. This leads inevitably to a certain formalism in the mode of presentation. Such formalism is not the best method for the high-school pupil. Correlation helps to avoid excessive formalism. Rigor need not be carried beyond the understanding of the pupil.

To illustrate, let us consider the topic of similar figures in demonstrative geometry. Ordinarily similar polygons are first

Digitized by Google

defined and this definition is then immediately used in the rigorous proof of certain theorems on similar triangles. When geometry and algebra are correlated similar triangles may be first used to furnish some concrete material for a certain type of algebraic work such as solving equations. For this purpose a scientific definition is not needed. It is quite sufficient to speak of similar triangles as triangles having the same shape. Later the pupil discovers by actual measurement that these triangles have equal corresponding angles, and that the corresponding sides are in proportion. He recognizes therefore that there is a valid reason for defining similar polygons as figures having equal corresponding angles and proportional corresponding sides, and that such a definition is rational as well as convenient and practical in the solution of problems and in the proof of theorems.

Ample time is allowed for the development of mathematical abilities. Frequently lack of experience results in inability on the part of the pupil. For example, many girls and boys are unable to appreciate demonstrative geometry because too little time is allowed for experiences that will lead to an understanding of the meaning of a geometrical proof. Some textbooks attempt to develop the ability in a few pages, with the result that the pupil in a few days after the beginning of a course in geometry finds himself deeply involved in a study which is difficult even for the adult. He is called upon to work with a number of geometrical concepts that are not all clear to him. Thus he thinks of a triangle when the theorem states angle. A rectangle represents to his mind a general quadrilateral. The term perpendicular means to him vertical. He sees no difference between a straight angle and a straight line.

The demand to use these and other concepts in a demonstrative proof which as yet has little or no meaning to him offers a second difficulty. Moreover, the whole study seems to him to lack real purpose, because the facts to be established are all such as he would readily grant without proof. He soon finds himself imitating or memorizing mechanically work which he does not understand. Many pupils are groping in the dark for months trying to get into the spirit of geometry. The pupil should meet these difficulties gradually, not all at one time. This is easily arranged where the mathematical subjects are correlated.

Thus in the first year the pupil may get much experience with the new geometrical concepts. Strong emphasis is to be placed

Digitized by Google

upon intuition, observation, description, and motor control. At first students should be taught to measure, to construct with ruler and compass, to recognize the fundamental forms of geometry in the classroom and elsewhere. This suggests many geometric truths. Concepts and facts discussed are to be expressed first in terms already familiar to the student, then gradually translated into the precise language of geometry. For example, he learns that similar triangles are triangles having the same shape. The exact definition is given later. The fact that measurements are at best only approximate, and are very tedious and difficult if carefully done, gradually leads to a desire for better methods and to a need for the logical method. In short, these experiences motivate the logical procedure. Toward the end of the year the pupil begins to establish facts by informal reasoning. The method of proof is to be always informal, its aim being to establish geometric facts and to prepare for, not to develop skill in, logical demonstration. Attempts at lengthy formal demonstration are to be made later.

The following example illustrates the method. It is required to find the sum of the angles of a triangle.

First method: Draw a triangle. Tear off the corners and place the angles adjacent to each other as in the figure below. What seems to be the sum of the angles of the triangle?

Later in the course when learning the use of the protractor this fact is established again as follows:

Draw a triangle. Fill out the table below with reference to this triangle.

Angle	Classify angle (Acute, Obtuse, etc.)	Amount of Rotation (Complete, Half, Less than Half, etc.)	No. of Degrees (estimated)	No. of Degrees (measured)	Error
a b c					
Sum					

The last method is the logical proof. Using the following figure in which DE is parallel to AC, prove that the sum of

Digitized by Google

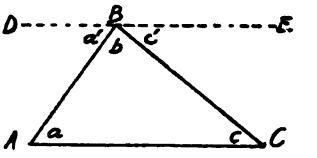
the interior angles of a triangle is two right angles.

Proof:

$a'+b+c' = 180.$ Why?
$a' = a.$ Why?
$c' = c.$ Why?

Therefore,

$a+b+c = 180.$ Why?



If a class is far enough along to understand a formal demonstrative proof, such work may be done in the second half of the first-year course, but rigor should never be carried to the point where the class is unable to appreciate it. The second year is the time to give extensive training in demonstrative geometry.

Similarly, in algebra, certain processes which logically belong together but represent real difficulty for the beginner may be separated in treatment. Thus the pupil should first become thoroughly familiar with unsigned literal numbers and with operations and laws of such numbers. Later he may review these operations and at the same time study positive and negative numbers, the laws of signs, and the operations with positive and negative numbers.

Correlation makes it possible to fit the subject more effectively to the needs of the pupil. Since both algebra and geometry contribute to the intellectual life correlation will make these subjects more productive for mental life and growth. The student who expects to take only one year of mathematics in the high school will acquire a knowledge of such geometric facts as he is most likely to make use of in later life; he will know enough algebra to prefer the algebraic method of solving problems to the less effective arithmetic method. He will receive training in both plane and solid geometry. Many theorems of solid geometry closely related to corresponding theorems in plane geometry should be taught in the second year, thus training the student in both two- and three-dimensional thinking.

The fundamental notions of trigonometry, usually kept from the student until the third or fourth year of high school, will appeal to him because of their usefulness as tools in problem solving. Hence these notions should be introduced at an early stage and so presented as to create no material difficulty for the beginner.

Correlation satisfies the demand for concrete mathematics. There is a real need for making concrete the abstract processes of algebra. No one teaching a course in calculus would think of de-

Digitized by Google

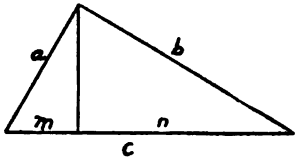
fining a fundamental concept like $f'(x)$ without concrete background. Likewise, the simple elementary concepts of algebra must be made concrete. This can readily be done by the early introduction of geometry which may be used as an aid in making clear algebraic principles and processes, and which furnishes to the pupil of high school age an abundance of concrete material. Not only is space available for use in geometry, but it is the *most available* material. For example, the symbols a, b, c may represent the lengths of the sides of a triangle, $a+b+c$ the perimeter, $a.b$ the area. The equation $a+b+c = 180$ may represent a relation between the angles of a triangle, and $a^2+b^2 = c^2$ a relation between the sides. Abstract processes of algebra can be made concrete, and important relations such as $(a+b)^2 = a^2+2ab+b^2$, and $(m+n)(c+d) = mc+nc+md+nd$ may be interpreted geometrically. The graph is used to illustrate the fundamental processes and to make clear the steps in the solution of equations. Thus the pupil is in less danger of juggling symbols without insight into the real meaning.

Needless reviews are avoided. Through the employment of algebraic notation and the continued application of the equation to geometrical matters firm hold is kept on algebra. The equation $x = y$ may express the fact that two lines are perpendicular; $x+y = 90$ means that two angles are complementary; AB = BC means that triangle ABC is isosceles. Many geometric facts are easily stated in algebraic form and many proofs are simplified by using algebraic notation.

For example, the proof of the theorem of Pythagoras which is one of the longest proofs in plane geometry and of considerable difficulty, assumes the following simple form with the use of algebraic notation:

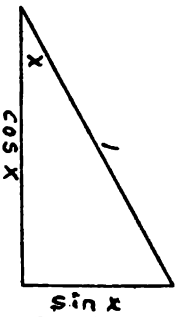
Proof:

$$m/a = a/c$$
$$n/b = b/c$$
$$a^2 = mc$$
$$b^2 = nc$$
$$\therefore a^2+b^2 = (m+n)c = c^2.$$



This constant use of algebra makes unnecessary long reviews of the first course such as are found in "second courses" in algebra, or at the beginning of a course in college algebra. The frequent use of theorems in furnishing principles for stating algebraic equations gives opportunity not only to review those theorems but also the proof.

Digitized by Google



Moreover, knowledge gained in algebra and in trigonometry is easy to recall when made concrete by geometry. For example, the triangle in the adjacent diagram establishes such relations as $\sin^2 x+\cos^2 x = 1$, $\tan x = \sin x/\cos x$, $\sec x = 1/\cos x$, and co-sec $x = 1/\sin x$. It also illustrates the changes in the sine and cosine functions as x is made to vary. By keeping this drawing in mind the pupil will easily recall these equations when they are needed.

Correlation furnishes motives for better methods and further study. The student sees the advantages of having various modes of treating the facts of quantity. The graph will bring out facts which are not easily detected from a study of a table; while the equation will give all these facts in a brief form which will readily yield a particular required fact.

For example, a table showing the consumption of electricity for each month during the twelve months of a year does not readily reveal certain facts which are easily detected by looking at a graph representing the data of the table. The graph not only gives these data but gives additional information. It shows that more electricity is used during some months than during others, that there is a gradual increase from month to month which is followed by a similar decrease. It leads the observer to inquire into the causes for these changes. It may even be possible to tell in advance what the approximate consumption is going to be for a certain month not designated in the graph. Similarly, a trigonometric table does not readily give any information regarding the changes of the sine function as the angle changes from 0° to 360°, while the graph pictures these changes very clearly. Moreover, the equation does not only give all the data of the table and those represented approximately in the graph, but may be used to give additional data. The graph of the equation $y = 3x+5$ may furnish corresponding values of x and y for values of x between -10 and $+10$. The equation itself, however, may be used to find values of y for any assigned value of x.

The superiority of algebraic over geometric or arithmetic methods is used as a motive for the study of algebra. Trigonometric methods, used to replace those of algebra and geometry, give opportunity to show the value of trigonometry and its advantages over algebra and geometry. Thus the student's

Digitized by Google

interest in subsequent studies is aroused and he is more likely to continue the study of mathematics.

Functional relations are emphasized throughout the course. These fundamental concepts are taught not only in the study of algebraic polynomials or in connection with trigonometric ratios, but also in the study of geometric figures. Thus, the areas of polygons are functions of given dimensions; the area of the circle is a function of the radius; the area of a triangle is a function of two sides and the included angle; the area of an equilateral triangle is a function of the side; the side of a triangle is a function of the opposite angle; an inscribed angle is a function of the intercepted arc. In this manner functional correspondence and functional thinking are constantly being emphasized.

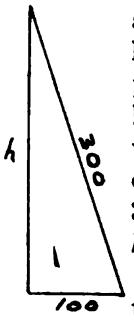
The question will be asked whether the results attained by a course in correlated mathematics are superior to those of the traditional courses.

There is an increased interest and enthusiasm on the part of the pupils which come with better understanding. Pupils may have difficulties but they never get lost so completely that they are not able to profit by instruction during the remainder of the course, as ability in one subject inculcates confidence in the other. In a standardized test which recently was given to all freshmen in the University of Chicago High School it was found that not only did they make a good showing in the work they had had, but that they did not hesitate to do types of work they had not studied in class. Several pupils succeeded in solving a system of simultaneous equations although that topic had not yet been taken up in class.

One of the best results, however, is the ability of pupils to apply mathematics in other high-school studies, such as physics, and in the more advanced mathematical courses such as college algebra and analytic geometry. Complaints which used to come frequently from the teachers of physics, when the traditional courses were given in the University High School, have entirely ceased.

There is a gain in mathematical power. When they make the acquaintance of only one subject in mathematics during the first year, many students fail to get an insight into secondary mathematics. Discouraged by failure in one subject, these pupils do not continue the study of mathematics, and thus they miss the opportunity to discover that they can be successful in another subject. However, in an introductory course in which

Digitized by Google



algebra and geometry are taught together, pupils soon learn to attack problems by various methods. A problem in indirect measurement, such as finding the height of a flag pole h, in the adjacent figure, may be worked geometrically by means of a scale drawing, or algebraically by solving the equation $h^2+100^2 = 300^2$, or trigonometrically by means of the formula $h = 100 \tan A$.

The ability to use various methods of attack and the experience of meeting problems in a large number of situations gives an excellent preparation for future college work. The reason why so many college teachers complain that high school pupils do not master the fundamentals of high-school mathematics lies mainly in the limited field of application. A pupil may master the solution of a quadratic equation with excellent results and be at a loss how to solve the equation $2\sin^2 x+3\sin x+1 = 0$. By correlating algebra, geometry, and trigonometry the pupil meets the fundamentals of high-school mathematics in a large number of situations.

This increase in mathematical power also results in a decrease in the number of failures.

One more important result of correlation is the saving of time. A representative high school class will cover in three years the work which in separate courses is usually given in one and one-half years of algebra, one and one-half year of geometry, and one-half year of trigonometry, or a total of three and one-half years. This has been accomplished in the University of Chicago High School for several years, as well as in a number of other schools, where the courses are correlated. The saving is not effected at a loss to the pupil, but is the result of a better arrangement, clearer understanding, and of time gained by making frequent reviews unnecessary.

PLATINUM FROM ALASKA.

The output of platinum, palladium, and other metals of the platinum group in Alaska in 1918 is estimated at 284 fine ounces, valued at $36,600, according to the U. S. Geological Survey, Department of the Interior.

Platinum was recovered from the gold placers of some districts in larger amounts and from some in smaller amounts than last year.

One of the most interesting events of the year in connection with Alaska mining is the recovery of substantial amounts of palladium and of some platinum from the copper ore of the Salt Chuck mine, near Ketchikan.

Digitized by Google

SUCH IS LIFE.

By ELEANOR J. OLMSTEAD,

High School, Antigo, Wis.

"Boy Wanted." The sign loomed huge and compelling before the door of Mr. Penner's grocery store. Mr. Penner showed rare judgment in putting it there just before the schools were out for all of the high-school boys stopped before his door on their way home from school.

"Say, fellows, there's my chance," yelled Sam Harris as he left them and burst into the store. "Mr. Penner, I'm your boy. What'll you give me? I'm some classy kid, all right—I ought to come high."

"Yes," drawled Mr. Penner, "the likes of you come altogether too high for me. Get out!"

And out Sam got. He felt a little chagrined but the bunch soon had him lively again and they raced off to the skating pond.

Jim Moffat came along after them and he too stopped in front of the store. Now Jim wasn't like Sam, not one bit, but he was a regular fellow just the same. He didn't have much money so the chance of a job appealed to him. It didn't make any difference to the boys whether Jim had money or not. He had the punch and pep which made him popular and which made the boys elect him class president and captain of the basket-ball team and a host of other things too numerous to mention. But still Jim kept going in the class room and when he took home his report card it was with no sense of depression but rather of elation because he knew that he had made good in a way that the home folks would appreciate. Oh, yes, as I said, Jim was a real fellow even if his kind were rare. And I forgot another thing—the girls liked Jim as well as the boys did. But don't think he was a sissy; girls don t like that kind. They liked him because he was big and clean and good fun and square in everything.

But to go back to our story. Jim was on his way home and he, too, saw the sign, "Boy Wanted." Before he had had time to think about it he went into the store and said,

"Mr. Penner, you want a boy. I want a job and I ll do the best I can to keep one. Will you take me?

Mr. Penner was delighted with Jim as people always were and engaged him on the spot and told him to come to work on the next day which was Saturday when Jim could work all day.

Jim was at the store bright and early and ready to begin work.

Digitized by Google

He swept out the store, he arranged the windows, he waited on customers, he did all sorts of things. At one time there was a lull in the number of people who came to get the sugar for Sunday's cake or the Sapolio for Saturday's scrubbing and Jim looked over to see Mr. Penner standing dubiously before two big—boxes of tea.

"Anything I can help you with, Mr. Penner? he asked.

"Wal, now, I don't know," drawled Mr. Penner, "but I don't no-hows think so. Ya see I'm in a fix, sorta. I got these here two boxes of tea and they are two different prices. But the folks what come in here want one price for their tea er else they's continually arskin' me what's the difference. So I'm aimin' ta sell it at one price. Now I want 120 pounds ta fill that there case of mine and I aim to sell it at 80 cents a pound. Now this here box costs 90 cents a pound and that there costs 60 cents. Now how much of each shall I take ta get my 120 pounds and sell it at 80 cents per an' not get cheated and not cheat the other fella?"

Jim's face beamed all over.

"Why, I can tell you how to do that," he said. "We learned to do that at school. Look here." He took a stub of a pencil from his pocket and, tearing off a piece of wrapping paper, started in.

"Now then, suppose we let x = the number of pounds of 60 cent tea you will take."

"That's enough, boy, that's enough," interrupted Mr. Penner. "I ain't got no patience with that there x and y stuff. It's all right in its place, is that there book-larnin stuff, but its place is in the school room, not in real business, see?"

"But, Mr. Penner, —"

"But me no buts, boy. It ain't no use."

"Just give me a chance to show you this much. I know I can find out what you want to know and it is much easier than if you tried to find out by weighing or figuring.

"Let x = the number of pounds of tea at 60 cents per pound.

"Then you want 120 pounds altogether, so $120-x$ = the number of pounds of tea at 90 cents per pound.

"Now, the value of the x pounds will be $60x$ since it costs 60 cents per pound and the value of the $(120-x)$ pounds will be $90(120-x)$ because it costs 90 cents per pound. Altogether the value of the mixture will be $60x+90(120-x)$. Now you want to sell this 120 pounds at 80 cents a pound so the value will be

Digitized by Google

120 times 80 cents or $96. But this is the value of the mixture. Now let's make an equation and solve it."

$$60x+90(120-x) = 9{,}600$$
$$60x+10{,}800-90x = 9{,}600$$
$$-30x = -1{,}200$$
$$x = 40.$$

"You need 40 pounds of 60 cent tea and 120−40 or 80 pounds of 90 cent tea. Then your 40 pounds will be worth 40×60 or $24 and your 80 pounds will be worth 80×90 or $72. Altogether they will be worth $96, the value of 120 pounds of tea at 80 cents per pound."

"Wal, wal," said Mr. Penner, "I swan. Can you do everything like that? By George, I'll raise you a dollar a day. Bring along your x and y if they can measure my tea for me. War did you larn ta do it?"

"Oh, that's just algebra," laughed Jim. "That's easy stuff but it does come in handy sometimes."

The day was soon over and Jim, with his extra dollar earned by his algebra, went home to sleep a tired sleep.

Now every real story must have a girl in it and since this is a real story I'll tell you about the girl. Her name was Ethel and she and Jim had lived next door to each other since they were babies, had graduated from the same grade school, and now were going to the same high school. Sunday afternoon when Jim came out on his front porch he saw Ethel going into her house and apparently thinking very intently about something.

"Hi there," he called across to her, "a penny for your thoughts. What's the matter?"

"Oh, Jim," said Ethel, "please come over and help me figure something out. I'm in a terrible mixup."

Jim was there in two bounds. "Now what's the matter?" he demanded, as they went into the house together.

"Well, you see it's this way. I'm treasurer of our Sunday school class and when we gave that play last week we decided to divide the proceeds. They amounted to $93 and there are seven of us. But Mary Dortman spent so much more time on it than any of the rest of us that we think she should receive five dollars more than any one else gets. I've tried figuring it every way and I always get balled up."

"Well, now," said Jim condescendingly, "there's where your algebra should come in. Just see here:

Let x = the amount for each of you.

Digitized by Google

But Mary gets \$5 more so she gets $x+5$.

There are six who get x dollars so that amount is $6x$.

Altogether you have \$93.

Then $6x+x+5 = 93$

$7x = 93-5$

$x =$ \$12.57, which is what each of you get

Mary gets \$17.57. Then you will have 1 cent left over since it doesn't come out even which I move you give to me for figuring it out for you."

"You're a brick, Jim," exclaimed Ethel. "I wish I could remember my algebra as well as you remember yours."

Now of course I don't claim that the algebra did it. It may have been mere propinquity but when the years had passed and Jim and Ethel decided to start housekeeping by themselves their friends laughed because they said that Jim must have worked out a proposal by algebra and that Ethel had had to agree because it was so logical. At any rate they had a great time preparing for the wedding even if folks did ask them if they intended to have the church aisles marked off in "x's" and "y's."

One day when Ethel was looking through her cake recipes trying to decide on the right one for the bridal cake she hit upon a very original plan and she immediately called up Jim to tell him about it. He came right over and they sat down to figure it out.

"You see," said Ethel, "I thought that I should like to include a recipe for my bridal cake in the box of wedding cake I am going to have for each guest. Usually if a recipe is to be made for more people it is just doubled or tripled as the case may be Wouldn't it be a good joke to write the recipe to include x so that the number of cakes could be substituted and the recipe hold good at all times?"

"It would be great fun," said Jim. "Why not do it like this? Write out your recipe for one cake and then add x to each part; for instance·

$2x$ cups of sugar,

$1\frac{1}{2}x$ tablespoonsful of butter,

$6x$ eggs, etc. Then add a note which will say to substitute for x the number of cakes wanted. Then no one would ever make a mistake and forget to double or triple any part of the recipe."

Ethel did as Jim had suggested and her algebraic cake recipe became the talk of the town.

After the wedding festivities were over and Jim and Ethel had

Digitized by Google

settled down in their own home, Ethel said one night, "Jim, I've decided to be very systematic in our household expenses. I'm going to decide just how much we should spend for food, for clothes, for amusements, and so forth, and then find out each month how closely we come to what I've decided on. I wish I could think of some plan of showing it better than just by figures."

"Well, how would this do," suggested Jim, "we'll make graphs just as we used to do in our algebra class. We'll make one graph which will show the ideal expenditures and then each month we'll make one for that month and as it goes above or below the ideal one so will our expenses go."

"That's a great idea," said Ethel, as she came and perched on the arm of Jim's chair. "Do you know, Jim, I've decided something. After all, no matter how unimportant what you learn in high school seems at the time there is always a use for it later on if you try to find that use. And that's true even for algebra."

"Yes, Ethel, I think you're right," answered Jim. "There's nothing in the world so hard or so disagreeable but what we find a use for it some time if we want to."

WEST INDIAN SURVEYS.

An increased appreciation of the value of scientific investigation in planning the wise utilization of natural resources has led several of the West Indian republics to seek the assistance of the United States Geological Survey, Department of the Interior, and to make cooperative agreements with it, whereby topographic and geologic surveys of the islands are to be made at the expense of their governments and the technical supervision of the work is to be assumed by the Geological Survey. The officials of these republics welcome this method of assuring the same quality of mapping for their areas as is obtained in surveys of the United States, and this appreciation of the aid thus given should lead to a larger American participation in the industrial and commercial development that ought to follow this inventory of mineral and land resources.

At the end of the fiscal year a general geologic reconnaissance had been made in the Dominican Republic, and arrangements had been completed for organizing the topographic surveys, field work to begin early in September. In the Republic of Haiti plans were perfected for similar work.

In a special message to the Cuban Congress the President of Cuba has urged an appropriation for the topographic and geologic survey of the island. The cooperative assistance of the Geological Survey has been promised by the Secretary of the Interior to a representative of the Cuban Government as well as in official correspondence, and it is expected that this largest of the West Indian projects will be begun within a year.

A geologic reconnaissance of the Virgin Islands of the United States and a part of Porto Rico with particular reference to ground-water resources was made in May and June. In Porto Rico a topographic survey also is desired by the local government.—Annual Report of Director, United States Geological Survey.

Digitized by Google

WEIGHTING OF DATA.

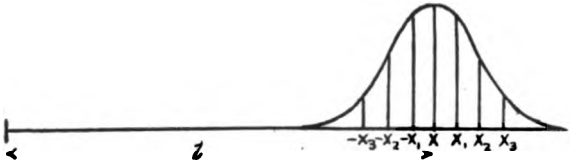
By J. P. BALLANTINE,

University of Maine, Orono, Maine.

The purpose of this paper is to suggest a method of weighting data, assuming that all the measurements are taken with equal care and are equally reliable.

Suppose one were measuring a quantity whose true value is l. The results are m_1, m_2, m_3, etc.; the errors are x_1, x_2 . . . etc.

Corresponding to x_1, x_2 . . . etc. erect ordinates. In the ideal case, when there is a large number of such ordinates their distribution will be denser near the small errors, and will gradually become less dense on either side. In fact, if the curve $y = Ke^{-h^2x^2}$ be plotted, these ordinates will cut off equal areas under it.



This condition will never be fulfilled in practice. Let us assume, however, that if there are n errors, x_1, x_2 . . . etc., and if we artificially cut the area under the curve $y = Ke^{-h^2x^2}$ into n equal areas by $(n-1)$ suitably chosen ordinates, that each x will fall in a different area.

Consider the various equal area enclosures as cages, and a particular variable x as a tiger walking to and fro, but kept in his cage by the above assumption. What effect will the corresponding change in m have on the average l?

Let w_1 be the weight of the m_1 concerned, and w be the total weight of all the other m's.

Let d_1 be the frontage of the cage.

Then

$$l_1 = \frac{m_1w_1+mw}{w_1+w}$$

$$l_2 = \frac{(m_1+d_1)w_1+mw}{w_1+w}$$

$$\therefore l_2 - l_1 = \frac{d_1w_1}{w_1+w} = \triangle_1 l$$

$\triangle 1$ is the effect on the weighted average l, of each journey of the tiger.

Digitized by Google

In reality, in place of one tiger, there are n tigers swaying back and forth according to their limited means, and with individual periods. The 'Keeper' would probably put the heavier animals in the center where their courses are shorter, and the lighter wild cats, etc., out further where their courses were longer.

In the same way, we would give a larger weight to the m with a smaller error x, in such a way as to make wd the same for all the n measurements.

$$w_1 = c/d_1 = cy.$$

Therefore, weights should be proportional to y.

A simple way of choosing weights proportional to y is to take coefficients of the binomial expansion $(1+1)^{n-1}$

Rule. Given n measurements of a quantity, arrange them in order of magnitude, and give them weights corresponding to the coefficients of the binomial theorem.

Note. As further evidence of the need for light weighting the largest and smallest m, elaborate methods have been devised for rejecting, i. e., assigning weight zero to the smallest or largest reading.

A PLEA FOR HIGHER SALARIES FOR TEACHERS.

Pointing out that an adequate wage for Illinois' 34,000 school teachers is the safest insurance for the future, a committee of 1,300 Chicago teachers have launched their drive to that end. They are devoting a half day's pay to further their cause.

A review of their share in the war is one of the arguments advanced by the teachers, who point out that their minimum wage request—$1,000 a year— is less than the sum earned by the humblest laborer.

Citing expressions from military men to prove that the Nation's triumphs in arms were due in large measure to the patriotism inculcated in the schools, the teachers point out that the teaching of American ideals must not be intrusted to teachers who are underpaid and thus tempted to instruct in radicalism prompted by a deep sense of personal wrong.

Radicals and anarchists are fully awake to the thriving field the groups of underpaid teachers offer, as the Chicago teachers have already been solicited three times this year by the I. W. W. and radicals of kindred doctrines.

"The duties of the schools now and for the future are the most important in their history," says a statement issued by the teachers, under direction of William T. McCoy. "The experiences of the war show that pro-German propaganda thrived where the American school had been neglected; that the large percentage of illiteracy was found only where vigilance in education had been relaxed.

"To correct that, more education is imperative. But teachers are finding the increased cost of living their chief difficulty, and despite years of sacrifice and preparation are being forced to quit.

"This must not be. The seriousness of the situation must be apparent to everyone."

Digitized by Google

THE DIFFERENTIAL PULLEY OR CHAIN HOIST.

By W. F. Roecker,

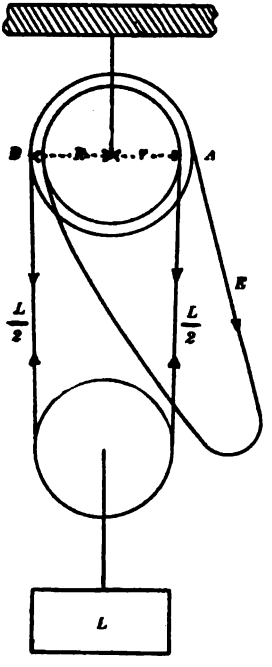
Boys' Technical High School, Milwaukee, Wis.

1. Diagram and describe the construction.

(a) Why call it differential?

(b) How is it like ordinary pulleys? How different?

2. The velocity ratio is a measure of the mechanical advantage.



(a) Show that $\frac{L}{E} = \frac{2R}{R-r}$.

(b) How would you construct a differential pulley with a high mechanical advantage?

(c) Find the M. A. if R = 10″ and r = 8″.

3. Input × Efficiency = Output.

(a) How is the input determined? The output?

(b) Define efficiency. How is it determined?

(c) What is the average efficiency of differential pulleys? Why is it so low?

(d) Why are sprocket wheels used?

4. Find the mechanical advantage and efficiency of a commercial differential pulley.

(a) Measure R and r and solve according to formula above.

(b) Measure D (effort distance) and d (load distance) and check against (a).

(c) Determine the force required to lift a member of the class; also determine the friction overcome.

(d) Calculate input, output and efficiency. Consider a lift of 5 feet.

5. Does the efficiency depend upon the load?

(a) Find the efficiency of this pulley in lifting a chair.

(b) How does this efficiency compare with that in (4)?

(c) Why is the efficiency not constant for small loads?

(d) How would you expect the efficiency to vary for larger loads, such as occur in actual service? See Ref. (b).

Digitized by Google

(e) What makes the load self-sustaining?

6. Calculate what force will be necessary to lift a member of your class whose weight is known. Check it by actually lifting him.

7. Problem. If it requires a force of 500 pounds to lift the front end of an automobile, how great a force must be exerted on the chain of this pulley to raise the automobile, if the efficiency is 30 per cent under this load?

8. What distinct advantages does the differential hoist offer?

REFERENCES.

(a) *Practical Physics*, Black and Davis, p. 30-31.
(b) *Elementary Practical Mechanics*, Jameson, p. 228-232.
(c) *Introductory Mechanics*, Bedford, p. 57-59.
(d) *Shop Arithmetic*, Norris and Smith, p. 126-128.
(e) *Encyclopedia Britannica.*

"THE HOLY LAND."

BY F. RENWICK.

How many visitors wintering in sunny Egypt have cast longing eyes towards the Holy Land but were afraid to embark on the short sea journey because of the uncertainty of landing at Jaffa! Now, they will be able to make the pilgrimage by rail all the way from Cairo to Jerusalem passing through a country of great biblical interest. Assuming the journey be made in the springtime, it will be especially delightful as the Plains of Philistia and Sharon are then carpeted with flowers. What a contrast to the sandy desert of Sinai first crossed!

Palestine still retains its unique attractions, both sentimental and otherwise. The traveler can now visit the various places of interest under conditions which never existed before.

Jerusalem, the capital, has a fine situation standing on four hills once divided by deep valleys which are now partially filled by the debris of successive destructions of the city. It did not suffer by bombardment in the recent campaign. Its ancient walls and picturesque buildings are just as before. Since the British occupation a number of improvements, mostly sanitary, have taken place and there is a feeling of security never enjoyed under Turkish rule. No longer is there any danger of falling among thieves on the way to Jericho. A dip in the Dead Sea (1,300 feet below sea level) or a swim in the River Jordan may be indulged in, with the certainty of finding one's clothes on the bank when required. The Church of the Holy Sepulchre can be visited, not once but several times, with pleasure and profit, there are many corners to explore and one just wanders around at will. The Mosque of Omar, standing on the site of Solomon's Temple, formerly only accessible to visitors escorted by a Turkish soldier and a consular canvass, can now be entered and all its details inspected at leisure while the dragoman points out anything of special interest.

The railway has been constructed from Ludd (Lydda) to Haifa. It is quite an interesting ride from Jerusalem to Haifa mainly along the Plain of Sharon. Just before reaching Haifa there is a good view of Athlit, the last stronghold of the Templars in Palestine and particularly interesting in view of the late war and re-conquest of the country by the crusaders of modern times.

Digitized by Google

A NEW METHOD OF RATING TUNING FORKS.

By W. H. Farr,

Laboratory of the Central Scientific Company, 460 East Ohio Street, Chicago, Ill.

When imports of scientific material were cut off by the European War, one problem presented to this laboratory was the rating of tuning forks, as the Central Scientific Co. soon undertook their manufacture on a large scale. Needless to say, standards were immediately provided for the pitches in most common use so that such forks could be tuned by direct comparison with a standard, but it was often required to rate small quantities of forks of unusual vibration numbers. For some time the method used was that of making tracings on a smoked drum, the time being determined by means of a seconds pendulum and a time marker. Altho the results were sufficiently accurate, the method was rather tedious for commercial testing where time is an important factor. With a view to overcoming this difficulty, we undertook to investigate the applicability of the stroboscopic method of the measurement of pitch, as developed by Dr. E. Seashore of the State University of Iowa in his "Tonoscope."[1]

The essential features of the Tonoscope are a revolving screen or drum, a synchronous motor for driving the drum at a constant speed, and a manometric flame device. On the surface of this drum are parallel rows of dots, each row containing a different number. The number of dots in each row corresponds to a certain pitch, there being sufficient rows to represent a complete octave. The drum is revolved at a speed of exactly one revolution per second. A tone is sounded in the mouthpiece of the manometric flame apparatus, producing a flickering flame, and the revolving drum is observed by the light of this flame. The row of dots which has the same frequency as this tone appears to stand still while all the other rows are apparently moving in one direction or the other. By means of a scale properly placed and numbered, the pitch of the tone is read off directly.

A modified form of this device was developed by Dr. L. E. Dodd while a graduate student at the State University of Iowa. In this form a small cylinder is used, being rotated by a phonograph motor of the Edison type. The sound whose pitch is to be measured is directed against a diaphragm, on the back of which is mounted a mirror. A beam of light from a lamp mounted

[1] *Science, Vol. XLIII*, No. 1113, April 28, 1916, page 592.
Electrical Experimenter, Vol. IV, No. 5, September, 1916, page 320.

Digitized by Google

behind the mirror is thrown on the rotating cylinder and the flickering of this beam of light by the vibration of the diaphragm gives the strobosopic effect described above.

When an attempt was made to adapt one of the above forms of apparatus to the problem of rating tuning forks, the following difficulties were encountered. The Seashore type is much larger than would be necessary for this work, the synchronous motor and its controlling mechanism is somewhat complicated, and the facilities at hand were not adapted to the graduating of a cylindrical surface. Also it requires that the sound be projected against a diaphragm, which is not readily done with a tuning fork. The Dodd type is much more compact and its mechanism simpler, and has the advantage of using a commercial type of motor. However, it presents the same problem of graduating a cylindrical surface, and also requires the sound to be projected against a diaphragm. Furthermore, as in both the above types a rather faint source of light is used, it is necessary to either darken the room or provide some kind of shade for the scale.

In the form which was finally developed in this laboratory a flat disk is used as a revolving "screen", it being rotated by means of any ordinary phonograph motor. The placing of the rows of dots on this disc was not difficult, as it was done in the circular dividing engine. The disc is 10 inches in diameter, having white dots on a black background. There are 34 concentric rows (or rings) of dots, containing every even number from 62 on the inner row to 130 on the outer row, giving a little over a complete octave. This is carried on the turntable of the phonograph motor, a scale being provided directly above it which indicates the number of dots in each row. The speed of the motor is controlled by means of the usual friction governor.

The first job on which this device was used was tuning some special forks of 117 and 127 v. p. s. which had screens or shutters on the end of the prongs. These shutters were provided with slits so arranged as to alternately open and close with each vibration of the fork. When the rotating disk is observed thru this slit, the stroboscopic effect described above is easily seen.

During the course of the above work the discovery was made that it was possible to rate a fork without having it provided with shutters. The fork is set in vibration and held so close to the eye that the edge of the prong almost obstructs the vision. In this position the prong of the fork swings in front of the eye at every vibration, giving an effect very similar to that of opening and closing a shutter.

Digitized by Google

This discovery increases the usefulness of this method considerably, as it makes it possible to rate any kind of fork without any alterations or attachments.

The procedure in rating an unknown fork is as follows: The disk is set in rotation and the speed is adjusted to one revolution per second by comparison with a standard 128 V. P. S. fork. The unknown fork is then set in vibration and held to the eye, and the vibration rate is read on the scale. Altho the rows on the disk contain only even numbers of dots, there is no difficulty in reading odd vibration numbers. In this case, no row of dots will stand still, but there will be found two adjacent rows in which the dots are moving in opposite directions at the same speed, indicating that the correct reading would lie just half way between. When the reading lies between two figures on the scale, it is possible by estimating the relative speed of the rows on either side to estimate the rate of the fork to within one half V. P. S. It is also possible to rate a fork whose tone is an octave above or below that represented by the numbers on the scale. The readings are taken in the same way and at the same disk speed, but in the first case one apparently sees twice the actual number of dots and in the second case half the actual number. If the speed of the disk were doubled, this would extend the range of the instrument at least one octave higher.

The accuracy of this method is limited only by the constancy of the speed of the motor. A spring motor would not be satisfactory for precision work, but is sufficiently constant for commercial testing. The fluctuations in speed occur largely at two points; just after the spring has been wound up, and when it is about run down. Between these two points very little attention is required to keep the speed regulated within the necessary limits of accuracy.

The following are some of the advantages presented by this type of construction.

Owing to the difference in diameters of the various rows it is possible to make the spacing of the dots approximately the same in each row, which is not possible in the case of a cylindrical screen.

If it is desired, a number of disks with different graduations may be prepared and used on the same machine, as they are easily changed as phonograph records.

With this device readings are taken directly, without the use of a manometric flame or vibrating mirror and without any attachments on the fork.

Digitized by Google

FORMULA FOR GROUP TESTS.

By Harold S. Hulbert, M. D. (*Detroit*),

Past Assistant Surgeon, National Naval Volunteers, U. S. Navy.

Incidental to the giving of group tests, a new formula for relative scoring was necessary. No existing formula was known which met all the requirements, so a new formula was evolved. This formula is $(T+MS)/(M+M^2)\times G$. It is applicable for scoring any group tests where the maximum of work which may be done in each test may be determined and where there are measurable variations in the total work done and in the success of the work done by the individuals tested. The symbols used may be thus explained: M = Maximum, S = Number of Successes, F = Number of Failures or Errors, T = Total, N = Number of tests, G = Grade, and % = Score.

The mathematica' accuracy of the formula depends upon the assumption that of M possible things to do, the perfect score shall be divided into M+1 parts, of which one part shall consist of the attempt without success to do the M things and the M parts shall consist of the M successes. Then an attempt to do one of the M things without success deserves a score of $1/M\times 1/(M+1)\times G$; an attempt to do T things without success deserves $T/M\times 1/(M+1)\times G$; an attempt to do T things with one success deserves $T/M\times 1/(M+1)\times G+1/(M+1)\times G$; and an attempt to do T things with S successes deserves

$$T/M+1/(M+1)\times G+S/(M+1)\times G = (T+MS)/(M^2+M)\times G.$$

The Maximum (M) is the greatest total any one in the group achieved, but after any test has been given and scored a great number of times, e. g. a thousand cases, the Maximum (M) for any test may be empirically set at the highest average, maximum. The Maximum (M) for any one test would not necessarily be the same as the Maximum (M) for another test. Note, in the original work based on one thousand cases and verified by forty-one thousand more cases, M = 75 on the so-called "cancellation test" and M = 50 on the so-called "code test" according to the conditions under which these tests were given.

The Grade (G) is the highest score obtainable on any one test, and is G = 100%/N or 100% divided by the number of group tests, e.g., if but one test is given G = 100%, if two tests are given G = 50.0%, or if three tests are given G = 33.3%. Note, in the original work two group tests were given, therefore G = 50.0%.

The Successes (S), the Failures or Errors (F) and the Total (T) of each individual in each test is noted when the work is corrected. As the Total (T) is the Successes (S) plus the Failures (F), T = S+F, only the Total (T) and the Successes (S)

Digitized by Google

need be considered in the computations, S and F being reciprocal. Total (T) may vary from 0 to Maximum and Successes (S) may vary from 0 to Maximum (M), but only in a perfect score would Successes (S) equal the Maximum (M).

Knowing the Maximum for any group test, the percentage of the possible Grade (G) for all possible combinations of Successes (S) and Total (T) may be computed and charted for reference. For daily use blue prints of the full chart may be used, cf. outline of chart, Fig. 1.

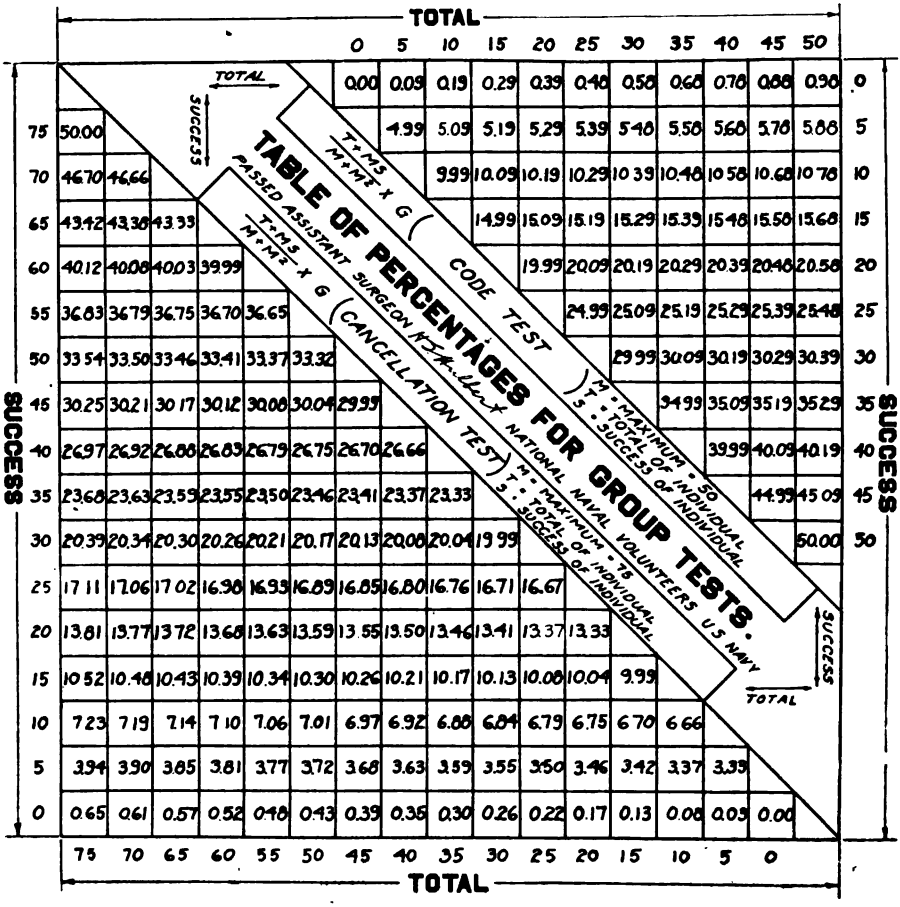

TOTAL
SUCCESS
TABLE OF PERCENTAGES FOR GROUP TESTS.
PASSED ASSISTANT SURGEON MATHEMATICAL EXAMINATION
T+MS / M+M² × G (CANCELLATION TEST)
T = TOTAL OF INDIVIDUAL SUCCESS OF INDIVIDUAL
M = MAXIMUM = 75
NATIONAL NAVAL VOLUNTEERS U S NAVY
T+MS / M+M² × G (CODE TEST)
M = MAXIMUM = 50

FIG. I.

Outline of chart shewing computed values of scores Total (T) and Success (S) as gra-ed by the GROUP TEST FORMULA $[(T+MS)/(M+M^2)] \times G$. For clarity in printing only the value of every fifth number is here charted.

Digitized by Google

A satisfactory formula for relative scoring of group tests must fulfill the following postulates:

1. The score must range from 0.0% to G or 100%; there must be no minus per cents.

2. Zero per cent must be only for absolute failure, i. e., not only no success, but no attempt or no total.

Example, by this formula, when S = 0, F = 0, T = 0, Score = 0.0%.

3. Without success, with minimum total (one) and with minimum failure (one) some per cent must be given for the effort. S = 0, F = 1, T = 1, Score = 0.01%.

4. With each increase of total but without any success there must be a slight increase in the score, i. e. no success, some failures but the total less than the maximum gives more per cent than the previous example. M = 75, S = 0, F = 37, T = 37, Score = 0.33%.

5. With further increase in the total but without any success is a greater per cent, S = 0, F = 75, T = 75, Score = 0.65%.

6. The minimum number of success must score more than the maximum number of failure, but with slight increase in the score for the increase of the total due to the increase of failures.

Examples:

S = 1, F = 0, T = 1, Score = 0.67%
S = 1, F = 36, T = 37, Score = 0.96%
S = 1, F = 74, T = 75, Score = 1.31%

7. With increasing success there is a rapidly increasing score, and with increasing total due to additional failures there is a slightly increasing score.

Examples:

S = 20, F = 0, T = 20, Score = 13.33%
S = 20, F = 20, T = 40, Score = 13.50%
S = 20, F = 55, T = 75, Score = 13.81%
S = 21, F = 0, T = 21, Score = 14.00%
S = 45, F = 0, T = 45, Score = 30.00%
S = 45, F = 10, T = 55, Score = 30.08%
S = 45, F = 30, T = 75, Score = 36.25%

8. Maximum success is maximum total (75) without any failures equals maximum per cent or Grade (G) which in this series of two group tests is fifty per cent.

S = 75, F = 0, T = 75, Score = 50.00%

Conclusion: By group tests time and effort may be saved. By the formula $(T+MS)/(M+M^2)\times G$ the work of the indi-

Digitized by Google

viduals tested can be relatively scored and comparisons made, and except for the total failures and the perfect successes the scores of the various individuals will be spread out like the vanes of an opening fan.

[1] $(T+MS)/(M+M^2)\times G = (T+MS)\times 50/(M^2+M)$. Here all the variables are grouped and multiplied by a constant. Resolving further it equals $[T+(75\times S)]\times 50/(75^2+75) = [T+75S]\times 50/5700 = (T+75S)\times 0.008771$. Therefore when Maximum (M) is 75 and this is one of two group tests (G = 50 per cent) knowing that 0.008771 is the constant, every possible value of T and of S may be computed, e. g.: T = 1, S = 0 or $(1+0)\times$ constant; T = 2, S = 0 or $(2+0)\times$ constant; T = 2, S = 1 or $2+(75\times 1)\times$ constant; T = 2, S = 2 or $[2+(75\times 2)]\times$ constant; T = 3, S = 0 or $(3+0)\times$ constant; T = 3, S = 1 or $[3+(75\times 1)]\times$ constant; T = 3, S = 2 or $[3+(75\times 2)]\times$ constant; T = 3, S = 3 or $[3+(75\times 3)]\times$ constant, etc. In charting, the totals may be the abscissae and the columns vary from 75 to 0, and the successes may be the ordinates and vary from 0 to 75.

Similarly when Maximum (M) is 50 and Grade is 50 (G = 50 per cent) the constant is 0.019607; ordinates and abscissae may be similarly computed and charted.

COST OF BUILDINGS IN 1918.

The United States Geological Survey, Department of the Interior, announces the publication of a report on building operations in the larger cities of the United States in 1918. This report shows the cost of such work in a large number of cities of the country for ten years and contains a diagram showing the great decrease caused by war conditions. It also shows the cost of buildings in these cities by character of buildings—that is, wooden, brick, stone, concrete, or steel skeleton buildings—and the cost of additions, alterations, and repairs, by classes of buildings. A copy of this report may be obtained by applying to the Director, United States Geological Survey, Washington, D. C.

ALASKA PRODUCES 70 MILLION POUNDS OF COPPER.

The copper production of Alaska in 1918 was 69,224,951 pounds, valued at $17,098,563, according to a report on the Alaska mining industry in 1918, just issued by the U. S. Geological Survey, Department of the Interior. This is less than the production in 1917, which was 88,793,400 pounds, valued at $24,240,598. The reduction in output is stated to be due to shortage of labor and ships. During the year seventeen copper mines were operated, the same number as in 1917. A copper prospect on the Alaska Peninsula is under development, and interest still continues, the report states, in the copper deposits of the Talkeetna and Broad Pass districts. The copper deposits in the Alaska Range recently reported are still attracting attention, although little work has been done on them. The deposit of copper discovered in 1915 on Rainy Creek, a tributary of the South Fork of Delta River seven miles above Miller's roadhouse, is said to be a large body of low-grade ore on which considerable crosscutting has been done. There is also a low-grade copper deposit in the gulch one and one-half or two miles west of Paxson's roadhouse. A copper lode on McLaren River, tributary to the Susitna, is said to be ten feet wide and of high grade. It was reported that an outfit was to be taken in on the snow in the winter of 1918-19 to prospect this deposit. A copy of the report may be obtained from the Director of the Geological Survey, Washington, D. C.

Digitized by Google

WHAT SHOULD THE PHYSICS TEACHER KNOW?

By C. L. VESTAL,

Carl Schurz High School, Chicago.

For generations the answer to a question like this about a teacher would have been: "He must know his subject." In the last two decades something has been happening to this assumption that knowing one's subject is the same as being a good teacher of it. "Knowing the subject" means vastly more today than it meant even ten years ago. Also, another phase has been added to the conception, viz., how the subject bears on actual life. Regardless of the subject taught, the teacher who would today keep the whole-hearted respect of his pupils must be able to at least bring in the atmosphere of actuality. High school pupils do not do much reasoning—wherein they are true to parental example—but they have an instinctive feeling for truth. If the teaching they get does not ring true to the test of life significance, they will have a kind of subconscious contempt for it, and the teacher comes in for his or her share of this contempt. Hence, as I believe, arises a proportion of the disciplinary difficulties and a considerable percentage of the "flunkers." What is the answer? *The teacher must know the bearing of his subject on life itself, and must contrive some natural, matter-of-course way to introduce this bearing into his teaching.* It must not be palpably dragged in by the ears, either, or it will fall flatter than the proverbial pancake. It must sincerely belong.

Applying this test to the subject of physics probably seems easy. The pupil's waking life is pretty largely a series of happenings in Physics. But the mere recognition of this fact is a very different matter from saturating one's teaching with it. You must know a great deal more than your "subject," in the old sense. This chiefly meant having at the end of one's tongue the statement and specialized methods of demonstration of the great physical laws, with especial emphasis upon accurate measurement and abstract calculation. Today, if you expect to be successful in keeping the respect and interest of your classes you must be a kind of general engineer, who is less interested in the formal verification of the laws than in their human uses. You must recognize and apply the great truth that *there is an emotional as well as an intellectual content to the branch of learning known as science.* You must learn to combine science and humanism.

Digitized by Google

Let me specify a little more closely. First, you must know the physical environment of your pupils in their homes, the shops, the streets, the fields. In approaching any physics topic have in mind this question: "In what way do my pupils make contact with this aspect of physics?" Start your attack with that fact, so far as possible. You must be the beginning of a household engineer, a sanitation engineer, an illuminating engineer, a civil engineer, an electrical engineer, a mechanical engineer, an automobile engineer. You are potentially a steam engine operator, an electrician, a movie operator, a gas engine repair man, a plumber, a glass blower, a machinist, a carpenter, an author, a psychologist, a policeman, a meteorologist, a draughtsman, an inspector.

Perhaps the most vivid way to make this matter seem definite is to state some of the questions that have been asked me, either spontaneously or at my own instigation, during the thirteen years I have been teaching physics. I believe these are questions which the high school physics teacher should for the most part be able to answer. I freely confess that there were many which I could not answer offhand when they were asked, and there are a few of them which I cannot answer offhand now. But they point the way. They show you concretely how the subject touches the lives of your pupils and their parents.

1. What makes "water hammer," and how can it be corrected?
2. Can you give the pupil an easy and simple method of testing out a bell circuit, a method which he can use at home?
3. Can you tell how to get at the magnetic door-latch, to correct its sticking?
4. Can you explain how to read the electric and gas meters?
5. Can you explain how the "central" girl makes the nickel drop down in the telephone box?
6. Can you explain how taking the receiver off the hook signals the operator?
7. Can you explain why the tungsten lamp is more efficient than the carbon filament lamp?
8. Can you explain how the receiver repeats the sound?
9. Can you explain why the nitrogen or argon filled lamps are more efficient than the ordinary tungsten lamps?
10. Can you explain why the candlepower of the lamp gradually diminishes?
11. What makes the faucets "chatter" sometimes? What is the remedy?
12. How can either of two switches turn the light off and on?
13. What are the main features of the Underwriters' code for house-wiring?
14. What are the rules upon which fuses are rated?
15. How are fuses tested for the time element?
16. How can you reverse the ordinary alternating current single phase household induction motor?
17. What is the reason for the soil pipe riser in a house?
18. What sizes of water pipe are allowable in residences?
19. What size is allowable to tap on to the street main from a house?

Digitized by Google

20. How does the water meter work?
21. How do the gas and electric meters work?
22. What are the relative merits of different types of lamp shades?
23. What lighting intensities should be used in a house, and why?
24. What relation should obtain between window area and floor area in living room lighting and in school room lighting?
25. How does the manufacturer determine the capacity of a furnace?
26. How do thermostats work?
27. What are the relative merits of the different forms of house heating?
28. How are the proper sizes of hot air registers determined?
29. Is sound transmitted much through a wall from room to room?
30. What kinds of walls reflect sound best?
31. What causes some rooms to make it so hard to understand in them?
32. What is the process of piano tuning?
33. Why do people sometimes build their house chimneys higher?
34. How does the interior design of hard coal furnace differ from that of a soft coal furnace, and why?
35. In actual use, are aluminum cooking utensils thermally any more efficient than iron ones? Why, or why not?
36. How do you take a faucet apart to renew worn out Fuller balls?
37. What is the difference in operation between the Fuller faucet and the compression faucet?
38. What are the relative merits of these faucets for household service?
39. Why is the sectional rocking grate for furnaces better than the old type in one piece, and shaking in a horizontal plane?
40. What makes the cuckoo clock "cuckoo?"
41. What are the processes in the manufacture of phonograph records?
42. Why do certain phonograph needles give louder sounds than others, on the same records?
43. Is it true that the phonograph record will not say certain sounds distinctly? If so, why?
44. Why do the piano hammers have felt on them?
45. How does the violinist get harmonics?
46. What makes the colored streaks sometimes seen in window glass?
47. How can you locate by experiment the center of gravity of a chair?
48. On what data are the sizes of furnace hot air pipes determined?
49. How long a nearly horizontal run of such pipe is permissible in residences, and why?
50. Does it pay to cover these hot air pipes with a heat insulator?
51. How much radiator area should be allowed per cubic unit of room?
52. What are the relative merits of the different types of steam heat?
53. Explain in detail the construction and operation of the heating system of the school building?
54. Can you describe the wiring layout of the school building? Of the typical residence?
55. What sizes of wire are required in house wiring?
56. What are the usual permissible sizes of fuses for residences?
57. Why does the wind whistle in the chimney?
58. Why does a high wind affect furnace or stove draught?
59. What causes the "spark" when a switch is opened?
60. Why does a carbon filament lamp light up more slowly than the tungsten filament?
61. Draw a diagram of a residence floor and mark in the best locations for the outlets and switches.
62. What makes an oil lamp smoke?
63. Why is the kitchen range interior designed as it is?
64. How do you adjust gas burners so that they will not "pop back?"
65. What is the service pressure of fuel gas?
66. How is this pressure maintained?
67. What are the causes of the fluctuations in the city water pressure?

Digitized by Google

68. Why does turning on the electric iron cause the lamps to get dimmer?
69. Why does the listener at the telephone sometimes hear faintly the talk upon other lines?
70. Why does the house plaster crack?
71. Why do dirt streaks come to show along the ceiling parallel to laths?
72. What are the dimensions of the ordinary room door in residences?
73. What is the best pitch for a shingle roof?
74. What is the best location for the kitchen sink, and why?
75. What is the best height for said sink, and why?
76. What is the most efficient positional relation among sink, stove, pantry, and utensil storage?
77. What is the approximate gas consumption of the different sizes of gas stove burners?
78. How can pupils determine this consumption at home?
79. What are the common tread and riser dimensions of the ordinary residence stairway?
80. About what maximum horsepower can the medium sized man exert?
81. How can one test his own horsepower simply?
82. What makes the automobile engine backfire sometimes?
83. What is the principle of carburetor regulation?
84. What is the approximate compression pressure in the automobile engine?
85. What is meant by the "firing order?"
86. Why is the firing order not consecutive from one end of the engine to the other?
87. What causes carbonization in the cylinders?
88. How can carbonization be minimized?
89. Why does the carburetor have an auxiliary air valve?
90. How does the vacuum system work?
91. Does the change in tire pressure due to temperature changes in operation ever endanger a tire in good condition?
92. Why is the cord tire superior to the ordinary fabric tire?
93. Exactly how, in detail, does the ordinary gear shift work?
94. How does the Ford gear-set work?
95. How is the automobile engine lubricated?
96. How does the clutch work?
97. Within about what distance should an automobile whose brakes are in good condition be able to stop on a level road from any one of four or five different and usual speeds?
98. What is the proper width of the spark gap on the spark plug?
99. How does the timer work?
100. Why does not the generator begin charging the battery until the engine has reached a certain speed?
101. At about what car speed, in high gear, does the battery begin charging?
102. How does the high tension magneto work?
103. How can you test whether a miss fire is due to the ignition?
104. How can you determine which plug is failing to fire?
105. What could cause an irregular or jerky running when all cylinders are firing?
106. How does the muffler "muffle?"
107. Why do motorcycles make more noise than automobiles?
108. What pressures are used in automobile tires?
109. Does the gauge pressure include atmospheric, or not?
110. How does the dial pressure gauge work?
111. Why is the steam automobile more powerful than the gasoline one? Or is it?
112. Why is there no need for gear shift in the steam automboile?
113. Why cannot the electric automobile go as fast as other kinds?
114. What is gasoline?

Digitized by Google

115. What is meant by "high test" gasoline?
116. Why does the oil in the crank case get bad?
117. Does the automobile ammeter show the current taken by the electric starter?
118. How does the locomotive reverse?
119. How does the air signal on the train work?
120. Where does the electricity for lighting a train come from?
121. How hard can a locomotive pull?
122. Can a locomotive pull be actually measured?
123. How many horsepower has a locomotive?
124. How much water does a locomotive use in an hour?
125. How much coal does it use in an hour?
126. What is the fastest a locomotive has ever gone?
127. What is the fastest an automobile has ever gone?
128. How is the speed of an aeroplane measured?
129. What makes a baseball curve?
130. Why won't the aeroplane engine run as well very high up as it does on the ground?
131. How high has a balloon ever gone?
132. How do they get the water into a locomotive boiler when steam is up?
133. Why do different locomotives have different numbers and sizes of wheels?
134. How steep a grade can a locomotive go up by itself?
135. How much higher is the outside rail than the inner one, on a curve?
136. What is meant by the "per cent" of a grade?
137. How does the safety valve work?
138. How does the track sander work?
139. Where is the sand carried on the locomotive?

It seems to me that a high school pupil's course in physics should answer these questions for him—or her. Not only these, but a great many more of the same general class. It is up to the teacher to be able to answer them, or at least to be able to direct the inquirer to an easily accessible source of the information. In most cases the equipment of the physics laboratory should consist partly of the literature—books and magazines— which will answer them. Most of them are not answered in the high school texts, except it be in such a remote and indirect way that no ordinary individual would see the implied answer. Probably no text should answer all such questions directly. At present there is a demand that our texts include, a great deal more than formerly, the discussion of applications of the great physical laws, and I think that demand is a wholesome one. However, I do not think it is the ultimate in method.

I believe that we shall gradually come to the project method in practically all our science teaching, so that no one text can possibly contain the course. In that case our texts will probably become briefer instead of longer, as is the present tendency, and carry only a commonsense discussion of the physical laws from the theoretical standpoint, with a very brief discussion of a practical illustration or example of each, followed by a rather

Digitized by Google

extended list of the other practical applications of the law. Learning the truths by means of their applications will then have to be left to the project, carried on in the laboratory so far as possible, but outside to a considerable extent. I have set forth the above questions merely as examples of what the physics teacher who really fills his job is up against. Know the laws and how to demonstrate them, both experimentally and mathematically, but this above all: *Know how they touch life.*

In a preprint from the forthcoming annual report of President Judson of the University of Chicago, attention is called to the fact that in the final gift of Mr. John D. Rockefeller, December, 1910, it was stipulated that $1,500,000 should be reserved for the erection of a University chapel. Under the architect appointed, Mr. Bertram A. Goodhue, of New York, the plans are proceeding steadily. This building, which is expected to be a beautiful specimen of Gothic architecture, will be adapted for all general religious services, and for such formal services as the various convocations. It will be erected on the east side of the block in which the President's house stands and will have a tower approximately 216 feet high. The highest towers at present on the quadrangles are those of the Harper Memorial Library with a height of 135 feet, and the Mitchell Tower 127 feet in height.

NINETY-NINE PER CENT FAVOR METRIC STANDARDIZATION.

Out of 58,226 petitions relating to exclusive use of metric weights and measures in U. S. America, now in the keeping of the Bureau of Standards, Department of Commerce, 57,800 petitions or 99.27% favor this progress, and only 426, or less than 1% oppose it. This unqualified endorsement of metric standards for U. S. America is brought out in the analysis just completed at Washington by representatives of World Trade Club of petitions sent to President Wilson and America's national legislators by prominent persons and powerful commercial, manufacturing, civic and fraternal organizations of U. S. America. Some of these petitions represent unanimous resolutions passed at conventions of organizations with thousands of members.

The petitions have come as a result of the efforts of World Trade Club of San Francisco and the Metric Association of New York in explaining the great advantages of world-wide standardization of weights and measures. The petitions were referred to the U. S. Department of Commerce, and without cost to the United States Government, World Trade Club had them carefully counted and classified under the direct supervision of Mr. W. Mortimer Crocker of 156 Fifth Avenue, New York City.

New petitions are coming every day. The classification to date shows the following distribution of petitions: Manufacturing concerns, engineering concerns, engineers, architects, and contractors were 9,968 in favor and only 154 against meter-liter-gram. Chambers of commerce, trade organizations, exporters, importers were 9,974 in favor and only 51 against meter-liter-gram. Educational institutions, beneficent organizations, individuals in professions were 22,443 in favor and only 74 against meter-liter-gram. Similarly, in all other vocations, although petitioners were free to declare for or against meter-liter-gram, less than 1% objected; and over 99% favored metric standards exclusively.

Digitized by Google

SOME IMPORTANT PHASES OF GEOGRAPHY.

By FRED K. BRANOM,
Geography Department, Chicago Normal College.

TREND OF MODERN EDUCATION.

One of the important questions which a geography teacher continually has confronting him is, "What is the goal of education in our country?" The goal of education has been defined recently as follows: "Education in a democracy, both within and without the school, should develop in each individual the knowledge, interests, ideals, habits, and powers whereby he will find his place and use that place to shape both himself and society towards ever nobler ends." (Cardinal Principles of Secondary Education, The Bureau of Education Bulletin, No. 35, p. 9, 1918). This means that as a citizen, a person must be able to take his part in the local, state, national, and international affairs of the day; as a worker he must adapt himself to a rather complex economic order and as a man of leisure he must be able to conduct himself sanely.

The World War has had an important effect on our mode of living and thinking. Man today is asking the meaning of various things and he is seeing new visions. Great political and industrial movements are taking place, many institutions appear to be tottering and a new world is awakening. Education has the leading part to play in this great onward movement. With such great responsibilities placed upon us, geography teachers are examining with new zeal the course of study. Questions are being asked concerning the advisability of teaching certain material, about the adaptation of the material to the pupils and about the proper methods of teaching. Is it true that if the material were selected, arranged, and taught properly that we could do better in six or seven years what we are doing now in eight years in the grades and that geography would find a hearty welcome in the high school? Such questions deserve our consideration, and Professor Judd has struck the keynote when he says that "the feeling has been steadily gaining strength that our generation must shake off institutional traditions of a past age and organize a sound scheme of democratic education." (Judd, Charles H.: *The Evolution of a Democratic School System*, 1918, Houghton, Mifflin Co.).

WHAT IS GEOGRAPHY?

Geography has undergone several important changes during

Digitized by Google

the last century and it is only recently that life has been recognized as a very essential factor. Until about the middle of the nineteenth century, geography consisted chiefly in memorizing answers to questions and in the location of places. Some of the text-books were entitled "Geographical Catechism" while others well might have been given such a name. Memory work was encouraged because it was thought that children had better memories than judgment.

Description gradually found its way into geography and by the end of the nineteenth century, geography was considered as a study of the earth and its people. The subject consisted chiefly of physical and locational geography. Life was given a secondary place.

As long as geography was thought of merely as a study of the earth and its people many things were included. It was a scrapbag into which went a mass of unrelated material. Confusion resulted and many people had the idea that geography was made up of the remains of various subjects, with locational geography as the center and memory work radiating in all directions. The child was given a condensed knowledge of the world and he was supposed to be a walking encyclopedia. Fact after fact was presented in almost the same way. Places, many of which the child never would have any occasion to use after leaving school, such as capes, peninsulas, straits, isthmuses, bays, oceans, lakes, rivers, mountains, plateaus, plains, and cities were located; the origin and meaning of many geographical names and the nicknames of the states were taught; and much time was spent in drawing the outlines of states, countries and continents by trying to reproduce the exact maps in the book. Life was mentioned occasionally but it was relegated to the background. The life of the school was not connected with the life outside the school. Is it any wonder that people began to question the teaching of geography and to ask "What is it?"

During the last ten years, geography has been given another meaning and the life element is occupying as much attention as the physical features. Geography is considered as a study of the earth in relation to life or the relation of life to its physical environment. Salisbury well expresses it when he says that geography "is to center about the influences of earth features and earth resources on the distribution, character and activities of life—life of all kinds.—It is actuated by the high motives of all science, one of which is the desire to render its truth service-

Digitized by Google

able to mankind. Its field overlaps, in varying degrees, the field of geology, physical geography, meteorology, botany, zoology, history, economics and perhaps other sciences. But it uses the facts and principles of these sciences in explanation of the distribution, character and activities of life." (Salisbury, R. D.: *Geology in Education*, *Science*, p. 334, April 5, 1918.)

Education has been affected greatly by the World War. Probably no subject has been influenced to such an extent as geography. When we began to read about places of which we had no knowledge we commenced to use our atlases and maps and we learned that this world is not so large after all. Our attention was turned to our own country and many were surprised to learn that the United States produces about three-fourths of the world's copper, two-thirds of the world's petroleum, one-half of the world's coal and iron, four-fifths of the world's corn, three-fifths of the world's cotton, one-fourth of the world's oats and one-fifth of the world's wheat. Our country has more than one-half of the known coal in the world, large deposits of iron and most other minerals, much undeveloped water-power and one-fourth of the land is forested. About one-half of the total area of the United States is available for farming and one-half of this is improved. We have the finest transportation facilities in the world, having not only about as many miles of railroad as all the other countries combined but also a system of great lakes. Thus we can see why the United States was an important factor in winning the war and why it is that we must take an active part in the affairs of the world. Can a country with such great resources and which in a very short time will be manufacturing for one-half of the world and will be carrying one-half of the world's commerce remain to itself? Rapid transportation by land, water and air, and the overcoming of time and space by the telephone and telegraph have made it impossible for such a resourceful country to remain in the background. Thus the importance of geography is readily seen. It teaches not only the location of places, commercial and industrial activities, but it instills in the minds and hearts of the children a love for this country, and above all, it shows the interdependence of man while at the same time it shows his dependence on nature. It deals more intimately and fundamentally with the welfare of the human race than any other science and fulfills the aims and the goal of education as given in the beginning of this paper. Geography should teach men not to dislike one another just because

Digitized by Google

they are different but it should show why they are different and interesting and how they are related.

The Teaching of Geography.

As long as geography is taught by a certain formula of dried facts it never will be interesting, but an inspiring and sympathetic teacher bringing out the big issues in each problem will be the guiding factor in contributing to the welfare of man. The subject of geography covers so much ground that we cannot expect a person to know everything about it or even a little something about everything which it includes, but we do expect him to have a knowledge of some of the things which geography covers and a real mastery of a small portion of them.

When a child enters school he has a rather large mass of geographic material which he began collecting shortly after birth. His preschool activity is to be carried into the school and it is to be enlarged and directed during the first few years by home geography. The home and its surroundings have a wealth of geographic material which may be obtained by a little search, and this material furnishes a basis for the study of the world. Old experiences must function constantly in obtaining and interpreting new experiences. Hence the process of learning which begins shortly after birth and ends with death is the gradual accumulation of related material based on our old experiences, it is the building of a world image. The duty of the school has been stated very clearly in the following words: "But if each one of us must do his own world building for himself, must see with his own eyes, hear with his own ears, image with his own imagination, classify according to his own purpose and be convinced of logical necessity through his own feeling of conviction, can the school do anything that is really worth while for him?—The school can do only one thing—it can offer a carefully selected environment in reaction to which the learner will use his own mind in socially profitable ways." (Moore, Ernest Carroll: *What is Education*, pp. 136-137, Ginn and Co., 1915).

The growth of the pupil should be progressive. The course of study should be so planned that the pupil is kept at something which is new and real, which is adapted to his capacity, and which is related to his former knowledge. It is to develop relationship by thinking. Much time is lost by repeating the same subjects in different grades while at the same time the love for geography is retarded.

Digitized by Google

To furnish the correct environment for the pupils several types of lessons are useful in the teaching of geography. Of course the only way of teaching is to follow the natural development of the child, but if one type is used continuously in motivating the lesson, lack of interest and attention will result.

Some of the more useful types in the teaching of geography are: (1) the problem-project lesson, (2) the journey lesson, (3) the review, (4) the topical lesson, (5) the type study lesson, (6) special reports, (7) dramatization, (8) the question and answer lesson, (9) the story lesson, and (10) the drill. There is no distinct line of demarcation between the types, in fact, several types may be used in one lesson, yet it is helpful to consider the material from the various viewpoints.

The Problem-Project.

A problem of considerable difficulty is a problem-project. (Branom, Mendel E.: *The Project Method in Education*, p. 145, Badger and Co., 1919). It may be considered as a problem of considerable difficulty arising from a situation and it involves the accumulation, the consideration, the interpretation and the evaluation of a mass of material for its solution.

The particular form of the problem is not nearly so important as the fact that the problem is the pupil's problem and that he has a keen interest in it. The pupil must feel a need for it. The duty of the teacher is to see that the pupils have the right sort of material such as maps, pictures, museum materials, magazines, newspaper clippings and supplementary readers from which to get problems and to solve them. It is indeed a waste of time in having pupils browse among a large mass of material when a few specific, well-directed instructions eliminate this.

To make clear what is meant by the problem-project a brief outline of a lesson on Brazil is given. Of course each teacher has his own particular motivation and the method of procedure is determined largely by him.

I. Preparation: Examine a population map of South America and note the population of the different regions.

II. Problem raised: Account for the sparse population of the Amazon Basin.

III. A consideration of (1) location, (2) climate, (3) vegetation, (4) surface features, (5) navigable streams, railroads and roads, (6) products of the forest, (7) mineral, pastoral and agricultural development, (8) character of the native population,

Digitized by Google

(9) competition of other regions and (10) difficulty of securing immigrants.

IV. Problem solved: The pupils will give their conclusion from the mass of material presented.

A problem may occupy one period or it may occupy several periods. Subordinate problems may arise from the main problem. Sometimes pupils are not able to solve the problems from the material collected and this is to be expected. There are many problems in life outside of school which are not solved satisfactorily and since the school is life there must be some unsolved problems in school.

The remark is made occasionally that if the problem-project method is used the course of study cannot be followed, that it is impossible to teach the work as outlined in geography. The course of study is a guide and an inspiration, not a taskmaster. The problem-project does not make war on any good course of study, but if used, it does mean the elimination of much useless material in some courses of study. If the material cannot be taught so that the pupil has a problem of his own to solve, in most cases it is safe to say that the material should be cast aside.

The Journey Lesson.

The journey lesson gives the pupils an acquaintance with the world. "The imaginary journey appeals to the play instinct of the child, requires the exercise of a vivid imagination, and when wisely used it becomes a profitable means of geography study. It brings reality into work, requires definiteness in planning, and is quite commendable when not overworked. It turns memorizing of facts into the enjoyment of present experiences, develops a sense of distance as measured by time or expense, gives familiarity with methods and routes of transportation, and develops an acquaintance with the facts concerning distant places, and the customs of their people." (Wilson, H. B. and G. M.: *The Motivation of School Work*, p. 147, Houghton Mifflin Co., 1916.)

The journey lesson necessarily lays much emphasis on the locational, descriptive and informational type of geography. Place geography which was taught formerly with no relation to anything is taught here with great advantage.

There are various methods of motivating and presenting a journey lesson and no two teachers conduct a lesson in the same way, but to give an idea of what may be done in a journey lesson

Digitized by Google

I shall give a lesson which was given with much profit to a fifth grade class. The journey occupied eight days.

JOURNEY FROM CHICAGO TO THE PACIFIC COAST AND BACK HOME.

I. Selection of route: By means of railroad maps of the United States and railroad folders and pamphlets the pupils noticed the different routes which they might take to the Pacific Coast and the points of interest. After careful consideration and some discussion the pupils decided to take the Atchison, Topeka and Santa Fe Railroad to San Francisco. (Classes have gone in groups over different routes but when they did so all met at San Francisco or some other Pacific port.)

II. Preparation for the journey: The pupils decided what they would take with them, such as clothing and money. All did not take the same articles.

III. From Chicago to San Francisco: As the pupils traveled they noticed the things of interest as they came to them, such as plains, plateaus, mountains, agricultural regions, grazing regions, mining regions, forested regions, fruit orchards and fisheries. The relation of well watered plains to agriculture, of the arid land to irrigation, dry farming and grazing; and mountains as forest reserves, pleasure resorts, sources of minerals, sources of streams, and barriers to transportation and communication were emphasized. States passed through were named and brief stops were made at places of interest. The pupils described what they saw and good short descriptions were given. Letters, which for the most part described the life of the region, were written for a little booklet which the class was making. Stereographs, pictures, text-books, supplementary readers and all available material were used.

IV. From San Francisco back to Chicago: The pupils decided to return home by way of the Pacific Ocean, Panama Canal, Gulf of Mexico, Mississippi River, Illinois River, Chicago Drainage Canal, and the Chicago River. The climate, products, vegetation, people and cities were noticed. Short stops were made at Panama, New Orleans and St. Louis.

V. Illustrated lecture describing the journey: To make the trip appear as real as possible and as a final impression an illustrated lecture by means of the lantern was given by the pupils. The slides consisted of geographic scenes along the route which the pupils had passed. Another class was invited to attend the lecture and the result was well worth the effort.

Digitized by Google

A journey lesson may occupy one period or it may occupy several periods. The interest of the class is the guiding factor. A beginner should not attempt very long trips at the start, but as the teacher increases in power the journeys may be lengthened. Journey lessons may be given in any grade but of course the character of the work will vary with the grade.

The Review Lesson.

The review lesson in the hands of many teachers is nothing but a cramming process. The pupils go over the past work with no new problems and the recitation is conducted in the old way. A review conducted in this way is a waste of time and it teaches the pupils poor habits of study.

To an increasing number of teachers the review does not mean the cramming process. The pupils have real problems to solve and they think of the material and arrange it in a different way. The pupils are led to see the previous work in a new light and from various viewpoints.

Recently a visit was made to an eighth grade class which was studying about wheat and the exporting of it. To see whether the pupils really understood what they had been studying, a few were sent to the the board without any previous instructions and were told to show in pictorial form the journey of the wheat from the field to New York City The results were surprising, yet highly encouraging. Each pupil in the space of about ten minutes put into graphic form the solution of his problem and it showed just what relationships he had formed in his mind. The drawings showed (1) rolling fields of wheat, (2) cutting the wheat and putting it in shocks, (3) threshing, (4) hauling the wheat to the elevators, (5) elevators, (6) wheat being taken by railroad to Superior or Duluth, (7) whalebacks on the lake, (8) map of the Great Lakes showing the chief cities, (9) railroad or Erie Canal and Hudson River to New York City. The next day to the teacher's surprise and delight, several of the pupils had the journey traced on large paper and two new scenes were added, (10) ship steaming from New York City, and (11) map of Europe showing the ports to which the wheat might be taken. The pupils were not instructed to do this but they became interested and they did it because they enjoyed it and felt they were doing something worth while.

Map sketching which is done usually in a half-hearted way became play. Will not the pupil remember a rough sketch of a region better if he has it connected with something vital? How

Digitized by Google

many of us have spent many hours learning to draw or to copy the maps in our books with no purpose except to please the teacher? How many of us can draw the same maps today? It is better to be able to make thirty rough sketches of different regions in thirty minutes than to spend thirty minutes in making one map.

In a fourth grade room the pupils had been studying about the customs and occupations of certain groups of foreign people. In order to leave lasting impressions, the pupils acted the life of the people. They put themselves into the work with all seriousness and the work was summarized in a beneficial way. Dramatization appeals to the child but in order to dramatize the work the pupils first must know it.

The last few paragraphs may suggest something about examinations and text-books. One of the main points to keep in mind concerning examinations is that there are various ways of giving examinations and that there are various kinds. Text-books are a guide to the pupils and teacher and probably have an important place in the American school, but the teacher who assigns so many pages in the book to be learned for the next lesson is teaching memory work, not geography. A text-book is only one of the sources which furnish geographic experiences. Just because examinations of a certain type were given to us when we went to school and just because the teacher was afraid to get away from the text-book is no reason why we should do likewise. Remember that "the old order changeth, yielding place to new, and God fulfills himself in many ways, lest one good custom should corrupt the world."

If geography is going to function properly, it must enter into the life of the child. There are no other subjects, unless they are modern history and sociology, which play such an important part in our lives, and if we can give to the pupils that sympathetic understanding of the world which is so essential to the welfare of man, geography will have performed its share in the education of the American youth.

GOLD AND PLATINUM PLACERS IN THE TOLSTOI DISTRICT.

The Tolstoi district includes an area about twelve miles wide by twenty miles long, which lies on the flanks of Mount Hurst. Most of the district is in the basin of Tolstoi River, on the branches of which placers that yield gold and platinum have been worked for several years. The topography, geology, climate, vegetation, and animal life of the district, the producing placers, and the economic factors that affect mining are described by G. L. Harrington in Bulletin 692-F.

Digitized by Google

PHYSIOLOGY IN OUR SCHOOLS.[1]

By W. E. Nelson,

Superintendent of Schools, Sabetha, Kans.

We are rapidly reaching the stage where great changes in our courses of study must take place. Some changes have already been made but the work in physiology is not receiving the attention it deserves. Not long ago the course in high school civics was extended from eighteen weeks to thirty-six weeks because so many students failed in their examinations; too much work was attempted for the length of time; but the number of physiology failures while perhaps not so great from the standpoint of grades, has been as great if not greater when measured in terms of real value to the students' experience. So long as people will be satisfied with formal teaching, giving folk catch phrases as "a sound mind in a sound body" and basing the entire work upon a half credit earned in passing the examinations over stuff crammed into the mind as so many facts, our teaching of physiology will be for the most part a failure. Mere words may be good and true but almost wholly purposeless and meaningless. When shall we learn that physiology is a practical subject—should be a required subject with adequate time for gaining a thorough knowledge of the work?

Before discussing the difficulties standing in the way of efficient work let me mention some facts to challenge our attention to the pressing need for this subject, and then state the aims of physiology teaching as set forth in the state course of study.

First, human life is the paramount issue with mankind, and yet Spencer tells us that one-half of life is thrown away.

Second, the needless cost of contagious diseases, in other words preventable diseases, for one year in New York city mounts into the millions of dollars and 28,000 lives annually are sacrificed victims of neglect. Add to the wages lost, doctor bills, and burial expenses of those who die, the expense caused by those who recover from sickness. Then add to these two classes the expense of preventable sickness that is not communicable but classed as preventive, such as indigestion, troubles caused by lack of sleep, adenoids, defective vision, spinal curvature, etc., and the economic loss is enormous. Wouldn't it be better to use

[1] Read before the Biology Round Table, State Teachers' Association, Topeka, Kans., Nov. 7, 1919.

Digitized by Google

this money to endow schools, lectureships and journals necessary to teach preventive hygiene in every section of this great country?

Third, statistics tell us that the diseases of old age are becoming common in middle life.

Fourth, during the last thirty years there has been an increase of one hundred per cent in deaths due to diseases of the heart, kidneys and other organs.

Fifth, thousands die annually of impure air; thousands die of typhoid, the filth disease, although we have made wonderful progress in checking its ravages.

Sixth, the work of shattering the nervous systems of the children in this country is increasing. We are producing an appalling crop of physical bankrupts.

Seventh, our cities spend at least six times as much money to prevent fire waste as to prevent life waste, while the latter is almost six times as great. This system makes property of more value than life.

These facts give us a glimpse of our problem, for the correction of such frightful mistakes must come through intelligence and our public schools are the greatest agencies in carrying out the campaign.

Now let us consider for a moment the aim as stated in our state course of study. "To promote the physical welfare of the child is the principal aim in teaching school physiology. This includes a knowledge of conditions favorable to growth and conducive to health and bodily vigor. Hygiene and sanitation treat of these facts. To teach the structure and functions of the body without hygiene and sanitation is to miss the highest value of the subject, whatever other values may be realized. On the other hand, to teach hygiene and sanitation without the elements of anatomy and physiology is to build on the sand with no scientific basis. Let this foundation then be adequate to an intelligent understanding of hygiene, but do not give all of the time and effort of the class to laying the foundation. Physiology properly taught is one of the most practical utilitarian subjects. The true scientific spirit should pervade the teaching of school physiology. It should be related to every day activities and conditions that affect health and should be made concrete and personal. Moreover the teaching of hygienic facts must be transformed into hygienic actions and hygienic actions into hygienic habits." Here is your program as outlined by the state course. There isn't a teacher within the sound of my voice

Digitized by Google

who can approach that aim in the time given for this work.

Now for our difficulties:

First, hygiene and sanitation are studied for nine months in the fifth grade, while physiology and hygiene are studied nine months in the seventh. When we reach high school, eighteen weeks are devoted to this subject in the junior year, and required only of those who plan to teach. Now beginning with the first grade in our public schools and passing through the high school, we note that mathematics begins the first year and extends through the eight years of the grades and at least two and one-half years in the high school, possibly four. English is the same, though it may not be called English in the early years. History begins not later than the sixth, often times earlier, and may be carried by the student through every year until graduation from high school. But to teach health, the laws of life, and the organic functions of the human body—this matter is insignificant in comparison with the above named subjects, and may be gained in the short space of time allotted to it by means of the text, a note book, and possibly some demonstrations with a beef heart. We must go to work diligently and seriously to get more time for this work. To call physiology one of the most practical utilitarian subjects in our course and attempt to learn enough to be of real value in so short a space of time is little short of mockery.

In the second place we lack trained teachers. At the present time physiology is a sort of foot-ball in most of our high schools. About the only requirement called for is the A. B. degree. Special training along this line is not necessarily demanded. Now when we consider the preparatory work offered below college grade, and with little or no preparation thereafter, we have little reason to expect much from our teachers in way of instruction and inspiration. With this lack of trained teachers necessarily goes a poor type of instruction. The work in the grades is so poorly taught, generally speaking, that the child not only fails to appreciate this subject but usually forms a strong dislike for it. To teach the facts of hygiene, recite upon them and issue grades or credit accordingly, is little short of useless. We need a great deal of material filled with human interest, and the teacher who is well prepared and really has a love for this work can make the subject inspiring rather than merely so much perfunctory work. The teacher may spend weeks in having recitations about the skin, pores, evaporation, and discharge of impurities, but to require shower baths will do more good than all the or-

Digitized by Google

dinary type of instruction. The child's attention may be secured more quickly for cleanliness of hands, and of teeth, by honoring him for it than by pages of Do's and Don't's in a textbook. Human interest may be gained in learning what city parks and outings do for sickly children; how the work of welfare committees improves health conditions in factories; how life insurance companies will not take risks upon lives of men and women who are addicted to intoxicating liquors and other forms of dangerous habits. To start out with a discussion in story form will do more by far than a dry recitation upon the number of bones in the human body or the evils of intemperance. When epidemics appear and absences are numerous, that is the time to make a lasting impression by asking pupils to keep track of absences due to these contagious diseases and follow up this scheme with a record and search for conditions favorable to this disease as well as means of prevention. This plan will do infinitely more than a dry recitation about people who die of plagues a thousand miles away. Our task is that of trying to get folk to live according to the laws of hygiene in an environment that is often times distinctly unhygienic.

Now what do we observe in connection with our high school teaching? First of all—it is a cramming process. There is more work outlined than can be covered in eighteen weeks if the work is to be done in a thorough manner. The text book, note book work suggested, and a certain amount of laboratory work in this short space of time, produce a jumble in the student's mind and he is more interested in getting just enough in his mind to pass examinations than he is to really understand the subject matter. On the other hand, if the work were extended throughout the year, the text used that we now have, although it is subject to rather severe criticism, supplemented by good assignments in other texts, together with a good laboratory course, and considerable outside reading, the results would soon begin to show. One unit of this work is too short, but if we can introduce into our high schools a one year workable course we could do nothing finer to advance the best interests of the students. The type of instruction now given is decidedly detrimental to real scholarship as well as to practical purposes. The teacher wishing to prepare the student for the normal training examinations selects such work as will most likely be called for, so the answers are memorized by parts, a-b-c-d. Note the questions extending over a period of years and you will observe that with a fair note book

Digitized by Google

and a cramming process worked to the limit, a student can pass the examination and yet know very little about the subject. Such work is unscientific to say the least.

We need a strong laboratory course in connection with our work and thus should place this subject on an equality, at least, with the other sciences. For example take the chapter on tissues and cells; too many teachers talk about these structures to a class as if they should have a perfectly clear understanding. As a matter of fact a little questioning outside the words of the text will reveal a vagueness in the minds of most students. It was the microscope that gave man a knowledge of what every living structure really is and the fashion after which it is constructed. Without time for a careful study and a certain amount of demonstration, the material in this chapter in deed and in truth becomes a "sell." We do not think of teaching other sciences without laboratory work; then why this one? Is it more important that a student should know through experiment the structure of plants and the laws of phsyics than that he should have a practical knowledge of the human body? Members of a class in zoology one year volunteered the information to me that after taking that course with laboratory work, many mysteries in physiology work had been made clear to them. This was the first time that the real significance of a physiology laboratory course came to me.

In addition to more thorough text book work where the emphasis is not placed upon passing the examinations, and a good solid laboratory course placing phsyiology on the same basis with other sciences, we need to add a third factor which remains practically unknown in the average high school: the value of wide reading as a form of experience. We are realizing more and more that the student must be prepared for actual conditions outside the school and not send him out unprepared to assume responsibilities in the social group. Many hygienic activities are carried on by the group, managed oftentimes by men especially trained for such work, but nevertheless there is a certain amount of oversight by the group. "We are too well satisfied with our technique of systematized learning." We need to broaden the student's understanding by historical, narrative and biographical sketches in connection with our class room work. We need to emphasize information from the text, to be sure, but we need development through wide and varied readings. We must not expect the student to retain all of this material, but

Digitized by Google

nevertheless the influence of such reading leaves its effect upon the general attitude of the mind that challenges our most serious attention. As one well known authority has said: "Reading experience is coming more and more to be valued as a means of forming mentality." There are many phases of activities in which actual experience and experience through accounts of others seem to be almost identical. When we reach lessons on food and food habits, for example, we need extensive reading which will actuate the planning of well balanced rations. Absolutely nothing is gained from memorizing the meagre information in the text. The diseases such as malaria, yellow fever and typhoid, for example, are read over, to be sure, but no lasting impression is made. The very thing we expect to do by these topics is not done at all. The work is meaningless. These are the things that need to make a lasting impression on the student's mind. Now if we had time to stress experience through readings, followed by discussions, we should make headway. For example, take some statement from a text book or pamphlet such as this: "The death rate in the Panama Canal zone was practically twenty times greater under French control than under American regulations." This fact merely as dry figures will not make a lasting impression on the student's mind but let him read an article such as appears in current magazines, an article containing the same fact throbbing with human interest, and his attention not only will be arrested but his sympathy will be aroused and the impression then will be permanent. The struggle that was waged against yellow fever in the south land and in Cuba; against bubonic plague on the western coast; struggles against the most insidious of adversaries are just as interesting as wars and struggles among nations. Heroic deeds in such accounts stand out as prominently and the results are those of positive upbuilding rather than devastation and destruction such as always follow in the wake of war. In our text book work we teach about a certain bacillus—travels, habitat, physiological effects, etc., but a grand lesson of social relationship we are likely to lose sight of: geographical and racial conditions, people most susceptible and those who seem to be immune, how affected by occupations, climatic and sanitary conditions. Go back to the days of the Pilgrim fathers and what hold had tuberculosis upon their redskinned neighbors? Primitive peoples the world over have been greatly reduced through the diseases of civilization. We must not stop in our study of tuberculosis with the matter of housing,

Digitized by Google

segregation and other means of prevention. The question of low wages means malnutrition and lowered vitality; lowered vitality means susceptibility to attack. We need more stress placed upon our work from a social standpoint. I have mentioned briefly only a few instances for the sake of illustration. We have a wealth of material on preventable diseases that we might use.

Advanced thinkers are beginning to demand a new profession —the profession of hygiene. This demand will not be supported extensively by the older generation but the young people in the schools of today will be responsible in bringing this change, when they take their places with the workers in every day affairs. The social group will have to exercise a greater degree of control over all forms of activity that affect the common welfare. The medical profession which is most closely related to the profession of hygiene will be responsible to society only in so far as society is able to hold it responsible. Quackery flourishes in an ignorant community. The different schools of medicine today conflict with each other and too often hinder progress. In spite of these opposing views, prejudice must be put aside. The fact must be recognized that there is only one body of truth which must be found through the scientific method, thus approaching as rapidly as possible toward this new ideal. If the public does not make this demand, who will make it and who will enforce it? Public sentiment is the greatest means of securing a high grade of service from any professional group. The day has passed when we can permit health to be squandered needlessly.

THE MONKEY STOPS CLIMBING.

By William F. Rigge,
Creighton University, Omaha, Nebr.

In the last December number of this journal, p. 815, Wilbert A. Stevens, Township High School, Lockport, Ills., takes exception to both the theoretical and practical solution of the problem of the climbing monkey that I had presented in these pages two years before, December, 1917, p. 821. This problem, as may be remembered, gave the case of a rope passing over a fixed pulley with a monkey clinging to one end while his equal counterpoise was attached to the other, and asked what happened to the counterpoise when the monkey climbed the rope. I said that it remained stationary, for the reason that, as the monkey could not change his weight, he could not increase his pull on the rope. I backed this up by an experiment in which a clockwork monkey weighing 240 grams was counterpoised over the nine-inch pulley of a fine Atwood's machine and climbed 80 cm. in a minute, while the counterpoise remained stationary.

As Mr. Stevens asserted that friction was to blame for the fact that

Digitized by Google

the counterpoise did not rise with the monkey, I had my doubts on the matter, because one-fifth of a gram was sufficient to destroy the balance. Let me add that the pulley had such a moment of inertia that its gross weight of 295 grams was practically equivalent to 150. To reduce this friction to still lower terms, the pulley was replaced by the beam of a balance so sensitive that 10 milligrams deflected the beam when the monkey and the counterpoise were attached. When the monkey started to climb, the counterpoise did go up for a moment, but it came down again and oscillated about its zero position with decreasing amplitudes. This confirmed me in my view.

However, discussion of the subject with my fellow professors convinced me that I was wrong and Mr. Stevens right in both theory and practice. In theory, because while the monkey cannot change his weight, he can change his acceleration, and this must be equalled by that of the counterpoise. This may be best shown if we let the monkey slide down the rope. As his pull is now lessened, the counterpoise must go down with him. For the same reason it must go up when he climbs. And again, if there were some weightless contrivance for shortening the rope over the monkey's head, because the pull is the same in both directions, both monkey and counterpoise must approach and go up together, just as equal boats must approach when the rope joining them is shortened. Placing this rope-shortening device in the monkey's arm muscles does not change the theory.

Now as to the experiments. In both, the force of acceleration was too small to overcome the inertia of the pulley and of the counterpoise. Taking out the last wheel in my clockwork monkey made him climb more than ten times as fast, and then both monkey and counterpoise went up together.

INCREASED OUTPUT OF ALASKA COAL.

The production of coal in Alaska in 1918 was 75,606 tons, valued at $411,850, according to the U. S. Geological Survey, Department of the Interior. This may be compared with 53,955 tons, valued at $265,317, in 1917. The production for 1918 was by far the largest in the history of coal mining in Alaska, being 40 per cent larger than the output for 1917, which was also greater than that of any previous year. It is believed that a substantial coal-mining industry has at last started in Alaska. The larger part of the output in 1918 came from the Matanuska field which yielded 63,092 tons. The remainder came from eight or ten small mines in different parts of the Territory. All these mines, except those in the Matanuska and Bering River fields and at Port Graham, produced coal for local use under free-use permits. About 12 mines were operated, employing 239 men for an average period of 254 days.

In the Matanuska field the Eska Creek mines were operated regularly throughout the year by the Alaskan Engineering Commission, to supply fuel for railroad and other Government use. At the Chickaloon mine, also operated by the Alaskan Engineering Commission, the work has consisted primarily of exploration and development, and only a small amount of coal, won incidentally, has been produced. In 1918 for the first time Matanuska coal was shipped beyond Anchorage. Private operations preparatory to mining were continued by two lessees in the Matanuska field, and some coal was mined by one of them, but their mines are not yet regularly productive. A detailed account of coal mining in Alaska is contained in a report on the Alaskan mining industry in 1918 just issued by the Geological Survey at Washington, D. C.

Digitized by Google

PROBLEM DEPARTMENT.

Conducted by J. O. Hassler.

Crane Technical High School and Junior College, Chicago.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. If you have any suggestion to make, mail it to him. Address all communications to J. O. Hassler, 2337 W. 108th Place, Chicago.

SOLUTION OF PROBLEMS.

626. *Proposed by Walter McNelis, Philadelphia.*

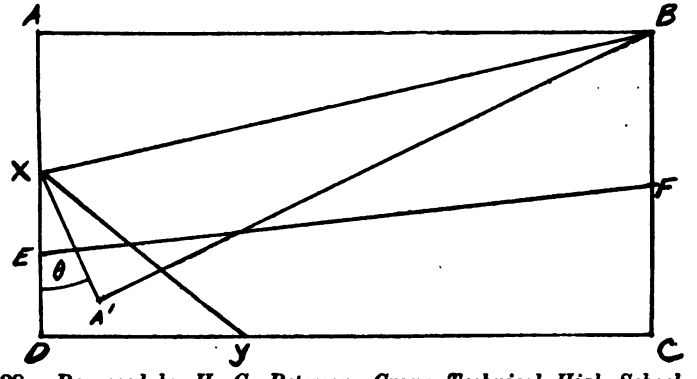
Prove the following equations are consistent and solve.

$$\begin{aligned} 50e_1+250e_2+100e_4 &= 6\\ 265e_3+200e_6-250e_2 &= 0\\ 110e_5-100e_4-200e_6 &= 0\\ 50e_1+265e_3+110e_5 &= 6\\ e_1- \quad e_2- \quad e_3 &= 0\\ -e_1+ \quad e_4+ \quad e_5 &= 0\\ -e_4+ \quad e_6+ \quad e_9 &= 0\\ e_7- \quad e_5- \quad e_6 &= 0 \end{aligned}$$

627. *Proposed by Daniel Kreth, Wellman, Iowa.*

If x be any prime number except 2, the integral part of $(1+\sqrt{2})_x$ diminished by 2, is divisible by $4x$.

There was an error in the statement of each of the above problems when published in the November issue. Although the correction was noted in the December issue, the delays in printing have brought this issue out so late that this material for February is being written very soon after publication of the correction. Therefore we will not publish solutions of the problems 626 and 627 until April and solutions may be sent in any time before February 20.



628. *Proposed by H. C. Peterson, Crane Technical High School and Junior College, Chicago.*

Suppose a rectangular sheet of paper has vertices indicated by A, B, C, D, consecutively. Fold corner A over along line BX, X any point in AD; fold again so that XD lies in the direction XB making crease XY (Y in BC or CD); open and fold again so that DC lies in line XB making crease EF. Prove that XY and EF make an angle of 45° with each other.

I. *Solution by Hazel C. Jones, Danville, Ill.* [By folding.—*Ed.*]

Call the point of intersection of XY and EF, Z. After making the crease EF, unfold and fold again so that DX lies in the direction BX. Without

Digitized by Google

unfolding, fold again so that YC lies along the line XB. It will be seen that the straight angle made by a line drawn from the point where Y falls on the line XB through the point Z is divided, by the folding, into four equal angles each of which is an angle of 45°.

One of these angles, YZF, is made by the intersection of the lines XY and EF.

II. *Solution by J. Carl Kamplain, Student, University of Chicago.* [By using equations.—*Ed.*]

Let A′ be new position of A, when paper is folded over BX and let $\angle DXA' = \theta$. Then $\angle BXA' = 1/2\ \angle AXA' = 90° - 1/2\ \theta$.

Suppose BX and CD, both produced, to intersect at Z. Then $\angle BZC = \angle BXA' + \angle DXA' - 90° = 1/2\ \theta$.

Hence $\angle FZC = 1/4\ \theta$. $\angle YXD = 1/2\ \angle BXD = 45° + 1/4\ \theta$.

Hence angle between DC and XY $= 135° - 1/4\ \theta$.

Hence EF and DC make angles of 135° and 45° with each other.

Also solved by R. C. Staley, A. Pelletier *and* M. G. Schucker.

629. *Proposed by Walter R. Warne, Carlisle, Pa.*

Give a solution by means of elementary plane geometry of the following:

If l, m, n be the perpendiculars from the center of the circumscribed circle on the sides of a triangle, show that

$$4(a/l + b/m + c/n) = abc/lmn.$$

I. *Solution by A. Pelletier, Montreal, Can.*

Let H be the orthocenter of ABC, and R, the radius of the four equal circles circumscribed to ABC, ABH, ACH, BCH.

From the equality

$$4R(ABH + ACH + BCH) = 4R \cdot ABC$$

we derive

$$a \cdot BH \cdot CH + b \cdot AH \cdot CH + c \cdot AH \cdot BH = abc.$$

But AH $= 2l$, BH $= 2m$, CH $= 2n$, hence,

$$4(amn + bln + clm) = abc,$$

or

$$4(a/l + b/m + c/n) = abc/lmn.$$

II. *Solution by William Bailey, Student in Dickinson High School, Jersey City, N. J.*

[This solution, Mr. Roray informs us, was the result of a request for a proof by synthetic geometry of the familiar formula tanA + tanB + tanC = tanAtanBtanC which is closely related to this problem.—*Editor.*]

Given triangle ABC with AD perpendicular to BC, BE perpendicular to AC, CF perpendicular to AB. Let AD $= h$, BE $= j$, CF $= i$, BD $= x$, DC $= y$, BF $= q$, FA $= p$, AE $= r$ and EC $= s$. To prove

$$j/r + i/q + h/y = jih/rqy.$$

$$h(x + y) = j(r + s) \quad (1)$$

$$y(x + y) = s(r + s) \quad (2)$$

$$x^2 + 2xy + y^2 - s^2 = j^2 \quad (3)$$

Subtract (2) from (3),

$$x^2 + xy + sr = j^2.$$

From this

$$xh(x + y) + hsr = jhj \cdot xs/xs = hij \cdot xs/yq.$$

$$x(js + jr) + hsr = jih \cdot xs/qy,$$

$$j/r + j/s + h/x = jih/rqy.$$

$$\therefore j/r + h/y + i/q = jih/rqy.$$

This at once reduces by similar triangles to

$$4(a/l + b/m + c/n) = abc/lmn.$$

III. *Solution by Nelson L. Roray, Metuchen, N. J.*

We have at once

$$la + mb + nc = 2\Delta \quad [\Delta = \text{area of triangle.}]$$

or

$$2R(a/mn + b/ln + c/lm) = abc/lmn \quad [R = \text{radius circum-circle}].$$

But

$$R : a/2 = mc/2 + nb/2 \quad [\text{Ptolemy's Theorem.}]$$

or

Digitized by Google

$$R = (mc+nb)/a,\ (lb+ma)/c,\ (na+lc)/b.$$

Whence by substituting for R in equation (2) we get

$$4(a/l+b/m+c/n) = abc/lmn.$$

or

$$a/2l+b/2m+c/2n = a/2l \cdot b/2m \cdot c/2n.$$

or

$$\tan A+\tan B+\tan C = \tan A \cdot \tan B \cdot \tan C.$$

630. *Proposed by Herbert C. Whitaker, Philadelphia.*

A ship at sea sights two lighthouses, one due north, the other due east. After sailing N.35°E., 3 miles, the ship is equally distant from the two lights; and sailing on the same course one mile further, the ship is found to be on the same straight line with the lights. What is the distance between the two lighthouses?

I. *Solution by A. Pelletier, Montreal, Can.*

Let O, M, N be the three observing points, where OM = 3, MN = 1. Let X, Y be the two light houses. Draw OP perpendicular to XY and represent the acute angle ONX by x.

We have

$$OP = 4\sin x,\ OX = 4\sin x/\sin(55°+x)$$
$$PX = -4\sin x \cdot \cos(55°+x)/\sin(55°+x)$$
$$XY = -4\sin x/\sin(55°+x)\cos(55°+x) \qquad (1)$$

Now

$$XY/2 = PX+OM\cos x = -4\sin x \cdot \cos(55°+x)/\sin(55°+x)+3\cos x \qquad (2)$$

Comparing (1) and (2), we get, after a few transformations,

$$4\tan x/3 = \tan(110°+2x).$$

Solving by approximation, we find $x = 73° 53'$, and XY = 7.86.

II. *Solution by the Proposer.*

Let A be the east lighthouse, B the north lighthouse and C, D, E successive positions of the ship. Let CA = x and CB = y.

$$AD^2 = x^2+9-6x\cos 55° = y^2+9-6y\cos 35°.$$
$$2 \cdot \text{area ABC} = xy = 4x\sin 55°+4y\sin 35°$$

whence

$$x = 4.9371, \text{ and } y = 6.12117 \text{ and AB} = 7.864$$

Another solution was also received from the PROPOSER.

Late Solution. A solution to 624 from the PROPOSER was received too late for publication in last issue.

PROBLEMS FOR SOLUTION.

641. *Proposed by Walter R. Warne, State College, Pa.*

Eliminate x between the equations

$$x+1/x = y$$
$$x^5+1/x^5 = z.$$

642. *Proposed by Abigail Glenn, Student, Chicago Normal College.*

What value of b will make b^4+30b^2+25 a perfect square?

643. *Proposed by Walter R. Warne.*

The sum of three terms of an harmonic series is 11, and the sum of their squares is 49. Find the numbers.

644. *Proposed by H. C. Peterson, Chicago.*

Suppose a rectangular strip of paper with vertices A, B, C, D, consecutively (AB representing the length). Fold on some line, say EF (E on AB, F on CD) so that EA will intersect FC in point G, say, making EFG an equilateral triangle.

645. *Proposed by Walter R. Warne.*

If $abcs = 8\triangle^2$, where a, b, c represent the sides of a triangle, s the semiperimeter and $\triangle$ the area, prove the triangle is equilateral.

GEOLOGIC PROBLEMS IN THE MATANUSKA COAL FIELD.

The results of studies of the strata and of the structure in the Matanuska coal field, Alaska, made in 1917 by G. C. Martin, are reported in a paper just published in Bulletin 692-D. The paper includes sections showing the character, relations, and thickness of the beds of rock and coal at many localities, as well as a graphic section showing a tentative correlation of certain coal beds between places specified.

Digitized by Google

SCIENCE QUESTIONS.

Conducted by Franklin T. Jones.

The Warner & Swasey Company, Cleveland, Ohio.

Readers are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, 10109 Wilbur Ave., S. E., Cleveland, Ohio.

Please send examination papers on any subject or from any source to the Editor of this department. *He will reciprocate by sending you such collections of questions as may interest you and be at his disposal.*

QUESTIONS AND PROBLEMS FOR SOLUTION.

The following test was prepared by a committee in cooperation with the Society for the Promotion of Engineering Education.

SCHOOL SCIENCE AND MATHEMATICS is under obligation to Dr. L. L. Thurstone, Division of Psychology, Carnegie Institute of Technology, Pittsburgh, Pa., for permission to print this test. Please note, however, that it is copyrighted by Carnegie Institute.

335. *Test V, Physics.*

Will readers of SCHOOL SCIENCE AND MATHEMATICS *try this test upon themselves and send in the results? Answers will be treated confidentially.*

TEST V, PHYSICS, FOR COLLEGE FRESHMEN AND HIGH SCHOOL SENIORS.

(Prepared for Society for the Promotion of Engineering Education, Committee No. 22 on Intelligence Tests.)

Time Limit: 30 minutes.

Name.....

College.....Date.....

Do not open this pamphlet until you are told to do so by the examiner.

This is a test to see how quickly and accurately you can think. The result of the test will be used by your advisers in order that they may know more about your abilities.

On the inside pages there are 25 problems. In each case you are told exactly what to do. Notice the instructions carefully.

Do not ask any questions. If you come to a problem that you do not understand, go to the next problem.

You will be given only thirty minutes. Solve as many problems as you can in the time allowed.

DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO BEGIN.

(Copyright 1919, by Carnegie Institute of Technology. Form S-1531.)

1. The six links of a chain can stand 50, 60, 70, 80, 90, and 100 lbs. respectively. It has been decided not to load the chain more than half of its maximum capacity. What is the largest allowable load on the chain?

   Answer.....pounds

2. What is the power consumption of a tungsten lamp that uses 1.5 amperes at 110 volts?

   Answer.....watts

3. A boy exerts a force of 75 pounds. How much work does he do in helping to push a truck a distance of 100 feet on a level road if the truck weighs 3,000 lbs.?

   Answer.....foot pounds

4. What is the angular velocity of the earth?

   Answer.....degrees per hour

5. A metal ball weighs 100 grams in air and 90 grams when suspended in water. What is the specific gravity of the ball?

   Answer.....

6. What is the velocity of sound when a note which has a frequency of 275 vibrations per second has a wave length of four feet?

   Answer.....feet per second

7. The area of the large piston in a certain hydraulic press is 50 square inches, that of the small piston is one square inch. What load can

Digitized by Google

be supported on the large piston if a force of 100 pounds is applied to the small one?

Answer.....pounds

8. A tree which is 100 feet from a pinhole produces an image which is 1 foot high on a screen 5 feet from the pinhole. How high is the tree?

Answer.....ft.

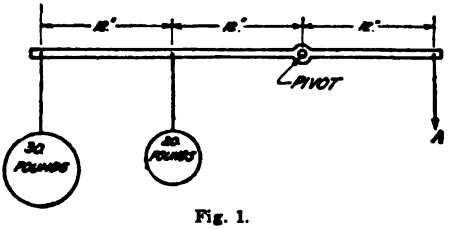


Fig. 1.

9. A ball rolls down an inclined plane with an acceleration of 20 cm. per sec., per sec. If it starts from rest, how far does it travel in seven seconds?

Answer.....cm.

10. What force is necessary at A in Figure 1 to balance the two weights on the other side of the pivot?

Answer.....lbs.

11. If the angle of incidence of a beam of light on a pond of water is 40 degrees, what is the angle of reflection?

Answer.....degrees

12. What is the pressure at the bottom of a tank filled with water if the tank is 30 cm. in diameter and 100 cm. deep? Neglect atmospheric pressure.

Answer.....grams per sq. cm.

13. If 1,000 feet of No. 18 copper wire has a resistance of 6.5 ohms, what is the resistance of 100 feet of the same wire?

Answer.....ohms

14. If 1,000 feet of No. 18 copper wire has a resistance of 6.5 ohms, what is the resistance of a wire of the same length and material and double the cross section?

Answer.....ohms

15. A certain bi-convex lens is placed at a distance of two feet from an object. An image is produced at a distance of one foot from the lens. The object is $1\frac{1}{2}$ inches in diameter. What is the diameter of the image?

Answer.....inches

16. If it requires 0.1 ampere to operate a certain electric bell, and the resistance of the magnet winding is 10 ohms, what is the lowest voltage that will serve the purpose?

Answer.....volts

17. A storage cell with a resistance of 0.1 ohm is connected in series with a resistance of one ohm. What is the value of the current if the e.m.f. of the cell is 2.2 volts?

Answer.....amperes

18. How many grams of water at 80° C will be required to just melt 5 grams of ice?

Answer.....grams

19. A cylinder contains 1,000 cubic inches of oxygen at a pressure of 50 pounds per square inch. What would be the pressure in the cylinder if the gas were compressed to 250 cubic inches at constant temperature?

Answer.....lbs. per sq. in.

20. An anemometer on a steamer indicates a wind velocity of 28 miles per hour from the northeast. The steamer however is moving due northeast at a speed of 15 miles per hour. What is the actual ve-

Digitized by Google

locity of the wind?

Answer.....miles per hour

21. What force is necessary at R in Figure 2 to balance the weight? Neglect the weight of the lever arms.

Answer.....pounds

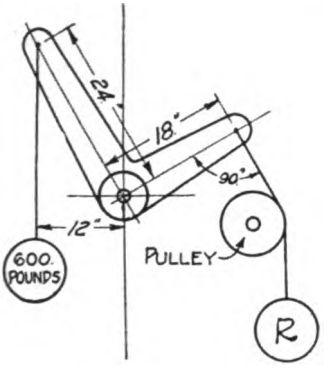


Fig. 2

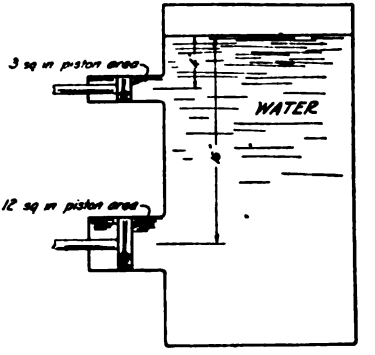


Fig. 3

22. Figure 3 shows a tank of water with two pistons. The force on the upper piston rod due to water pressure is ½ pound. What will be the force due to water pressure on the lower piston rod?

Answer.....pounds

23. A man exerts a downward force of 100 pounds. How much can he support with a tackle consisting of one fixed and one movable pulley?

Answer.....pounds

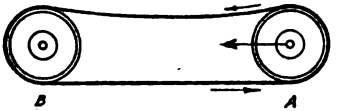


Fig. 4

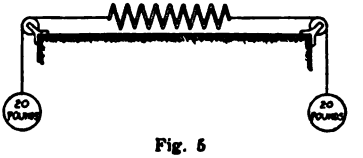


Fig. 5

24. Figure 4 shows two pulleys connected by a leather belt. The pulley A is the driving pulley. The bottom side of the belt is the tight side, and the total pull in it is 360 pounds. The pull on the slack side is 100 pounds less than on the tight side. What is the total pull on the shaft in the pulley A in the direction of the large arrow?

Answer.....lbs.

25. The elastic limit of the spring in Figure 5 is 70 lbs. It elongates one inch by a force of five pounds. How much would the spring be elongated by the two weights as shown in the figure?

Answer.....inches

SOLUTIONS AND ANSWERS.

328. *The Canal Problem published in the October, 1919, number.*

No correct solutions have been received.

333. *Proposed by H. J. A. Hackenberg, Manager, The Cleveland Instrument Co., Cleveland, Ohio.*

Can you devise (or locate) an equation for the current in the galvanometer of a Wheatstone bridge circuit when voltage of battery and resistance are given?

Solution by Robt. W. Boreman, Georgia School of Technology, Atlanta, Ga.

This is scarcely a practical problem for the Wheatstone bridge as used in practice, for measuring resistance is balanced so that there is no current flowing through the galvanometer. For an unbalanced condition, when current does flow through the galvanometer, it may be calculated

Digitized by Google

from a consideration of Kirchoff's laws: (*a*) The algebraic sum of all the currents flowing toward a branch point is zero. (*b*) The algebraic sum of all the electromotive forces acting around a closed circuit, or a mesh of a network of conductors is equal to the sum of the products ri around the mesh.

In the Wheatstone bridge circuit shown (and in the problem as stated) we are to know the resistance of each part—r_1, r_2, r_3, r_4, r_5, and r_6— and the e.m.f. "E." The unknown values of the current in each branch—i_1, i_2, i_3, i_4, i_5 and i_6 may be found by solving the following equations simultaneously.

$$\begin{aligned} i_1-i_2-i_3 &= 0 && (1)\\ -i_1+i_4+i_5 &= 0 && (2)\\ i_2-i_4+i_6 &= 0 && (3)\\ i_3+i_5+i_6 &= 0 && (4)\\ r_1i_1+r_2i_2+r_4i_4 &= E && (5)\\ -r_2i_2+r_3i_3+r_6i_6 &= 0 && (6)\\ -r_4i_4+r_5i_5-r_6i_6 &= 0 && (7)\\ r_1i_1+r_3i_3+r_5i_5 &= E && (8) \end{aligned}$$

Equations (1), (2), (3), and (4) come directly from the first law given above by considering the branch points *a*, *b*, *c* and *d* in the order named. The mesh equations (5), (6), (7), and (8) come from a consideration of the second law considering currents flowing in a clockwise direction around the mesh as positive and those in the opposite direction as negative. We get eight equations and have only six unknowns so one may be dropped from each set leaving the six independent equations to be solved for the six unknowns.

If it is desired to solve for only the galvanometer current i_6, it is easiest to do it by determinants using the following equations:

$i_1 = i_2+i_3$, $i_2 = i_4-i_6$ and $i_3 = i_5+i_6$. Combining these with (7), (6), and (5) above we get the equations: $r_6i_6+r_3i_3-r_2i_2 = 0$; $-i_6(r_6+r_5+r_4)+i_3r_5-i_2r_4 = 0$ and $i_6r_4+i_3r_1+i_2(r_1+r_2+r_4) = E$

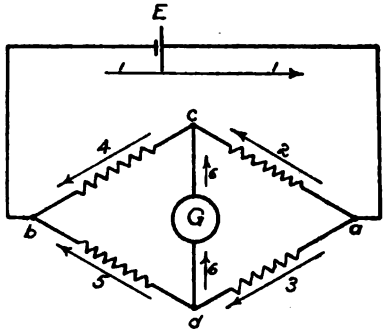
Writing D for the determinant

$$\begin{matrix} r_6, & r_3, & -r_2 \\ -(r_6+r_5+r_4), & r_5, & -r_4 \\ r_4, & r_1, & r_1+r_2+r_4 \end{matrix}$$

Then for the value of i_6 the galvanometer current, we have

$$i_6 = \frac{E(r_2r_5-r_3r_4)}{D}$$

From which $D = r_6r_5(r_1+r_2+r_4)-r_3r_4r_4+r_2r_1(r_6+r_2+r_4)+r_3r_5r_4+r_3(r_6+r_2+r_4)(r_1+r_2+r_4)+r_6r_1r_4$



In case it seems desirable to work out a specific case let us take the following: r_1, including the battery resistance and that of the leads, is 50 ohms. r_2 is 250 ohms. r_3 is 265 ohms. r_4 is 100 ohms. r_5 is 110 ohms and r_6 is 200 ohms and includes the resistance of the galvanometer. The battery has an e.m.f. of 6 volts. The following is a method of determining i_6:

Digitized by Google

$$i_6 = \frac{E(r_2r_5 - r_3r_4)}{D} = \frac{6(250\times110 - 265\times100)}{D}$$

$$D = [200\times110(50+250+100) - 250\times100\times100 + 250\times50(200+110+100)] - [-250\times110\times100 - 265(200+110+100)(50+250+100) - 200\times50\times100]$$

$$D = 8{,}800{,}000 - 2{,}500{,}000 + 5{,}125{,}000 + 2{,}750{,}000 + 43{,}460{,}000 + 1{,}000{,}000 = 58{,}635{,}000$$

Then $i_6 = \frac{6\times1{,}000}{58{,}635{,}000} = 0.0001024$ Ampere.

Since the sign comes out plus, the current flows as assumed in the drawing. If it had come out negative, the flow would have been from *c* to *d* in the diagram.

GOVERNMENT IN TOUCH WITH OIL INDUSTRY.

The close contact of the United States Geological Survey of the Department of the Interior with the economic situation in the United States and its recognition of the need for the discovery of new oil fields in the immediate future is shown by the emphasis placed on geologic field investigations aimed at the discovery of new oil and gas reserves. Of the fourteen papers or short reports published in the annual volume of "Contributions to Economic Geology, 1918," Part II, *Mineral Fuels* (Bulletin 691), eleven relate to the possibilities of discovering new oil fields or of developing oil shales, whereas three are concerned with descriptions of coal fields. Three of the papers describe regions of favorable structure, with oil and gas possibilities, in Montana, one in North Dakota, two in California, one in Oklahoma, one in Arkansas, and one in portions of the Central Great Plains of Wyoming, Nebraska, Colorado, New Mexico, and Kansas.

Advance editions of these papers, distributed separately, were issued promptly as printed in order to place the information as soon as possible in the possession of the oil companies. The complete volume may now be obtained by addressing the Director of the U. S. Geological Survey, Department of the Interior, Washington, D. C.

WATER POWERS IN SOUTHEASTERN ALASKA.

Systematic investigation of the water resources of Alaska was begun by the United States Geological Survey, Department of the Interior, in 1906, and has been carried on in one or another part of the Territory to the present time. This investigation was undertaken to supply the need for definite information in regard to the quantity of water available for many uses, such as hydraulicking, dredging, and supplying power for mines, canneries, and sawmills.

The investigation of the water resources of southeastern Alaska was begun by the Geological Survey in cooperation with the Forest Service in 1915 and was designed to determine both the locations of water-power sites and the possible water power available. Since then the Geological Survey has maintained a number of gauging stations in southeastern Alaska throughout the year and has installed other stations in cooperation with individuals and corporations. The records obtained at these stations in 1918 are contained in a report entitled *Water-Power Investigations in Southeastern Alaska* (Bulletin 712B), by Geo. H. Canfield, which has been recently issued by the Geological Survey and can be obtained free of charge from the Director of the Survey at Washington.

Digitized by Google

A SURVEY REPORT OF COMMERCIAL EDUCATION.

No. 5 of Volume II of the *Supplementary Educational Monographs* is ready for distribution. It is entitled "A Survey of Comercial Education, in the Public High Schools of the United States," by Leverett S. Lyon instructor in the School of Commerce and Administration of the University of Chicago.

In the earlier sections of the monograph the following topics are discussed in detail: the kinds of commercial courses in public high schools, the length of such courses, the required subjects in each course, and the relative importance of technical and content subjects in commercial courses.

Inasmuch as the study is based on an investigation of commercial education in one hundred and thirty-six high schools in twenty-six different states, it is the most extensive study of its kind which has yet been made. Special consideration is given in the monograph to the social-business subjects. Such discussions are particularly appropriate in view of the increased importance, during recent years, to the business world of a thorough knowledge of commercial organization, economics, accounting, commercial law, and business organization.

One of the final chapters entitled "Plans and Policies in Secondary Commercial Work" discusses the significant needs of commercial education in a thoroughly constructive way. The monograph will prove very suggestive to superintendents and high-school principals who have supervision of commercial courses. It should be read by teachers of all phases of commercial education.—*School Review.*

LARGE STEEL MANUFACTURER DECLARES METRIC STANDARDIZATION EASY; NOT EXPENSIVE.

Speaking for one of the large steel manufacturing companies of the United States, R. H. Page, Vice-President of the Truscon Steel Company, New York City, and Manager of the Foreign Trade Department of the Truscon Steel Co., of Youngstown, Ohio, has just declared to the World Trade Club of San Francisco, that in the steel industry, the advance to metric standardization could be made easily and without appreciable cost. Mr. Page declares that his company strongly favors the adoption of metric standards exclusively by the U. S. of America. He asserts that foreign transactions would be greatly simplified by dealing in metric units and that the foreign trade of the United States would be greatly advanced.

He declares that there are no real difficulties in the way of adoption of metric standards. "The heavy equipment in the basic industries—such as rolls in the steel industry—are of short life and could be entirely replaced with metric sizes in 2 or 3 years' time," he declares. "The more complex tools and dies would require somewhat longer to replace, but, meanwhile, the products thereof could be listed in their present metric equivalents. Many of our larger firms in certain lines already maintain duplicate equipment for the manufacture of metric sizes for their foreign markets, thus recognizing the importance of getting into step with the majority of the civilized nations."

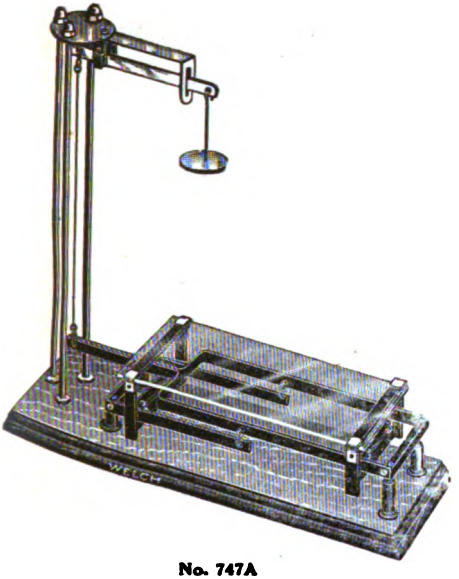
Some of the other large steel manufacturers supporting metric standardization are: R. T. Crane of the Crane Co., Chicago; The Tacony Steel Co. of Philadelphia; The Victor Animatograph Co. of Davenport, Iowa; Standard Steel Car Co., Butler, Pa.; Hamilton Watch Co., Lancaster, Pa.; American Wire Fabrics Co., Chicago, Ill.; The Hydraulic Pressed Steel Co. of Cleveland, Ohio; The American Insulated Wire & Cable Co., of Chicago, Ill., etc.

Digitized by Google

A Mark of Quality **WELCH SERVICE** From a House of Service

Apparatus of the highest quality and service that helps you select and use it.

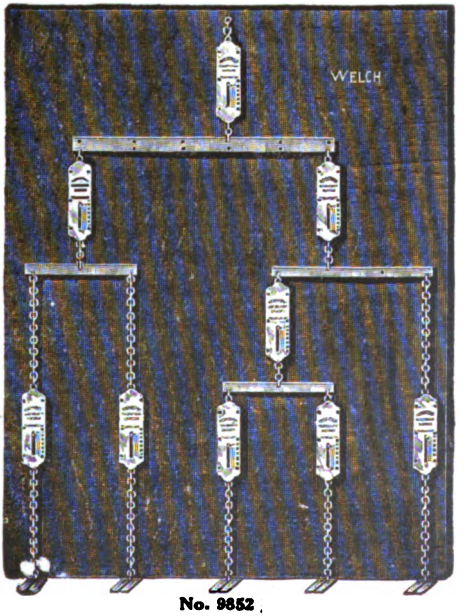
Two New Welch Specialties



No. 747A

No. 747A. DEMONSTRATION BALANCE, New form. Showing the principle of the farm scales and especially valuable in vocational or agricultural classes. It is the only form of balance that will correctly illustrate this principle. Suspended form of platform eliminates friction. High sensibility and multiplying power of about 75 times. As a demonstration piece it is of distinct value and also presents a valuable problem of levers for the student. Size of base 4x10 inches, 12 inches high.

No. 9852. EVENER APPARATUS. This is a superior form of apparatus for parallel force demonstration. It can be used in the laboratory to show the principle of moments and the laws of parallel forces. It is the only form of this apparatus which is not unstable until the last weight is added. It has the advantage over all other forms in that it makes the application especially plain and by its use can be illustrated the forces involved in the 2, 3, 4 and 5 horse hitch. This makes its use in vocational and agricultural courses of exceptional value. Complete as illustrated with 9 spring balances reading up to 64 ounces and 2 kg. in one oz. and 25 gm. divisions.



No. 9852

Write for new Catalog G on Physics and Chemistry Apparatus, new Catalog A on Agriculture Apparatus and Supplies, and new Catalog of Wireless Apparatus for Schools

W. M. Welch Scientific Company

Manufacturers, Importers and Exporters of Scientific Apparatus

1516 Orleans Street Chicago, Ill., U. S. A.

Digitized by Google

CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

At the November meeting of this Association held at Lake View High School, Chicago, the following officers for 1920 were elected:

President—J. A. Foberg, Crane Technical High School, Chicago.

Vice-President—Frederick R. Gorton, State Normal College, Ypsilanti, Mich.

Treasurer—Lewis L. Hall, Morgans Park High School, Chicago.

Corresponding Secretary—Ally L. Marlatt, University of Wisconsin, Madison.

Assistant Treasurer—E. S. Tillman, High School, Hammond, Indiana.

The Recording Secretary, Harry O. Gillet, the University of Chicago, was elected last year for a two-year term.

Biology—Chairman, Grace J. Baird, Bowen High School, Chicago; V. Chairman, C. P. Shideler, Joliet Twp. High School, Joliet, Ill., Secretary, Elizabeth Foss, North High School, Minneapolis, Minn.

Chemistry—Chairman, B. J. Rivett, Northwestern High School, Detroit, Mich,; V. Chairman, George Sype, Austin High School, Chicago; Secretary, K. J. Stouffer, Wayland Academy, Beaver Dam, Wis.

General Science—Chairman, G. A. Bowden, University School, Cincinnati, Ohio; V. Chairman, George Mounce, LaSalle-Peru Twp. High School, LaSalle, Ill.; Secretary, Ruth C. Russell, Lake View High School, Chicago.

Geography—Chairman, Wellington D. Jones, The University of Chicago, Chicago; V. Chairman, R. R. Robinson, Joliet Twp. High School, Joliet, Ill.; Secretary, Anne B. Royeston, Hyde Park High School, Chicago.

Home Economics—Chairman, Harriet Glendon, Lewis Institute, Chicago; V. Chairman, Treva E. Kauffman, Ohio State University, Columbus, Ohio; Secretary, Maude M. Firth, Supervisor Home Econ., Davenport, Ia.

Mathematics—Chairman, M. J. Newell, High School, Evanston, Ill.; V. Chairman, W. E. Beck, High School, Iowa City, Iowa; Secretary, Elsie G. Parker, Oak Park High School, Oak Park, Ill.

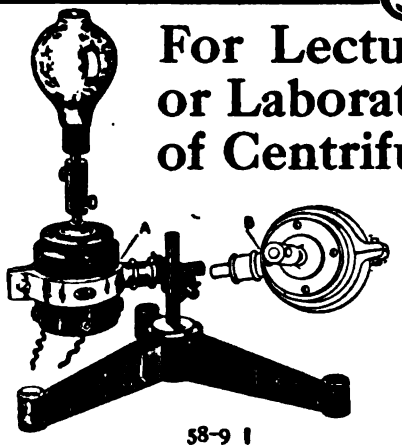
Physics—Chairman, H. Clyde Krenerick, North Div. High School, Milwaukee, Wis.; V. Chairman, C. F. Phipps, State Normal School, DeKalb, Ill.; Secretary, Glenn W. Warner, Englewood High School, Chicago.

The reports of the various sections' meetings will appear in the March issue of this Journal. They will make a very complete and comprehensive review of the entire transactions of the recent convention. The next meeting will be held in Chicago.

Recently, engineers, assembled from all parts of the world, celebrated the one hundredth anniversary of the death of James Watt. The three days celebration was held at Birmingham, England, where Watt lived and died. To his genius are due the steam engine, steam pump, steam railway and steam turbine. But Watt himself considered his greatest achievement the invention of a decimal measuring system whose three principal units became meter-liter-gram.

The strong movement on foot in America at the present time for the exclusive use of these rational units in the United States is a belated tribute to the genius of this great man.

Digitized by Google



58-9

For Lecture Demonstration, or Laboratory Application, of Centrifugal Force . . . . .

You Need This Waverley Electric—
A Whirling Machine and Centrifuge Combined.

As a whirling machine the Waverley-Electric takes a Centrifugal Globe (as illustrated), or Double Hoops, Centrifugal Balls, and other accessories.

A Centrifuge Head converts the Waverley-Electric into a powerful centrifuge that may be used with efficacy for the analysis of milk, urine, blood, or other liquids.

The specially designed, ball-bearing motor is mounted and balanced to operate in vertical or horizontal position. Consequently its general utility includes the rotation of Savart's Wheels, Siren Discs, Newton's Color Discs and the like.

The Waverley-Electric Specifications

Support—Standard Tripod.
Yoke—Cast Aluminum.
Housing—Enameled Iron.
Motor—6,000 R. P. M.
Mica Insulation. Self-Adjusting Brushes.
Ball-Bearing Shaft.
Current—D. C., A. C., or Dry Cells.
Chuck—Universal.

58-9	The Waverley-Electric, including Support, Yoke, Motor and Chuck	$19.00
58-9a	Waverley Centrifuge Head, four-arm	3.75

Cambridge Botanical Supply Company
LABORATORY EQUIPMENT—ALL SCIENCES
1-9 Lexington Street 1884-1919 Waverley, Mass.

ARTICLES IN CURRENT PERIODICALS.

American Botanist, for November; *Joliet, Ill.; $1.25 per year, 35 cents a copy:* "Plant Names and Their Meanings," Willard N. Clute; "A Little Known Botanist," J. E. Nelson; "The Haunts of a Naturalist," H. Tullsen.

American Journal of Botany, for November; *Brooklyn Botanic Garden, $5.00 per year, 50 cents a copy:* "A Study of Some Factors in the Chemical Stimulation of the Growth of Aspergillus Niger (Concluded)," Robert Aaron Steinberg; "An Index of Hardiness in Peach Buds," Earl S. Johnston; "Notes on the Dasheen and Chayote," Heber W. Youngken; "The Development of the Gametophyte and the Distribution of Sexual Characters in Funaria Hygrometrica," Mabel Mary Brown.

American Naturalist, for November-December; *Garrison, N. Y.; $5.00 per year, $1.00 a copy:* "Inheritance of White Spotting and Other Color Characters in Cats," P. W. Whiting; "Some Habitat Responses of the Large Water Strider Gerris Remigis Say," C. L. C. Riley; "Behavior and Assimilation," Henry D. Hooker, Jr.; "On the Use of the Sucking-fish for catching Fish and Turtles," E. W. Gudger; "Variability in Flower-number in Vernonia Missurica Rof," H. A. Gleason.

Condor, for November-December; *University of California, Berkeley: $2.00 per year, 40 cents a copy:* "Bird Notes from Saskatchewan," H. H. Mitchell; "A Return to the Dakota Lake Region," Florence M. Bailey; "Notes on the Elegent Tern as a Bird of California," Joseph Grinnell.

Journal of Physical Chemistry, for December; *Ithaca, N. Y.; $4.00 per year:* "Some Studies in Fondant Making," Mary S. Carrick; "The Colors of Colloids," Wilder D. Bancroft; "Emulsification at an Oil-Water Interface," "The Effect of Chlorine on Periodic Precipitation," Miss A. W. Foster.

Physical Review, for November; *Ithaca, N. Y.; $7.00 per year, 75 cents a copy:* "On the Distribution of Energy in the Visible Spectrum of an Acetylene Flame," E. P. Hyde, W. E. Forsythe and F. E. Cady; "On the Spectrum of X-Rays from an Aluminum Target," William Duane and Takeo Shimizu; "Studies of the Absorption of Gases by Charcoal, II," Harvey B. Lemon and Kathryn Blodgett; "The End Correction in the Determination of Gas Viscosity by Capillary Tube Method," A. F.

Digitized by Google

Benton; "The Radiating Potentials of Nitrogen," H. D. Smyth; "The Reflection Factors of Tungsten at Incandescent Temperatures," W. Weniger and A. H. Pfund; "Reflection of Electrons from Metal Surfaces," H. H. Dadourian; "Remarks on Dr. L. Silberstein's Results in his Paper 'On the Dispersion of the Diamond,'" Albert C. Crehore; "An Experimental Method for the Production of Vibrations," C. V. Raman.

Popular Astronomy, for January; *Northfield, Minnesota; $4.00 per year:* "Twenty-Third Meeting of the American Astronomical Society (Concluded)"; "The Reform of the Julian Calendar (Continued)," Roscoe Lamont; "First Study of Heavenly Bodies," Mary E. Byrd; "A Criticism of Pickering's Suggested Explanation of the Phenomena Presented by a Nova," A. C. Gifford, with Reply by W. H. Pickering; "The Annular Eclipse of November 22, 1919. The Lunar Atmosphere," W. H. Pickering; "Astronomical Phenomena in 1920."

School Review, for January; *University of Chicago Press; $1.50 per year, 20 cents a copy:* "Some Aspects of a Junior College," C. C. Alexander and G. W. Willett; "The Ben Blewett Junior High School of St. Louis—Part I," R. L. Lyman; "A Failure Class in Algebra," O. A. Wood; "The Social Life of High-School Girls: Its Problems and Its Opportunities," Olivia Pound; "A High-School Program for Training in Citizenship," Thomas Warrington Gosling.

Scientific Monthly, for January; *Garrison, N. Y.; $5.00 per year, 50 cents a copy:* "Defects Found in Drafted Men," Dr. C. B. Davenport and Lieutenant Colonel Albert G. Love; "The Haven of Health," Dr. George E. Simpson; "The Disadvantages of Being Human," Professor B. W. Kunkel; "The Mechanism of Evolution in the Light of Heredity and Development," Professor Edwin G. Conklin; "Growing Plants as Health-Giving Agents," Dr. James Anders; "The Microscopic Identification of Commercial Fur Hairs," Dr. Leon A. Hausman; "The Deflection of Light by Gravitation and the Einstein Theory of Relativity"; "The Origins of Civilization," Professor James H. Breasted.

EDUCATIONAL NOTES.

It is a matter of common knowledge that the increased cost of production of to-day is in large measure due to the demand on the part of labor for shorter working hours and more pay. The common way of the manufacturer of meeting this increased cost has been to pass it all and a little more on to the consumer by greatly raising the price of the commodity.

At the Athenaeum Press, where Ginn and Company's books are manufactured, there has just been inaugurated a plan of training foremen, forewomen, and other factory supervisors in production methods. A three-months' course is being conducted by the Business Training Corporation of New York for a group of forty-six, composed of the treasurer, press manager, department heads, and all foremen from the man in charge of a room of fifty to the one who supervises the work of two or three. The work consists in the study of especially prepared subjects, the solution of problems relating to each subject, and the discussion of this material at six bi-weekly meetings. At each meeting a lecture is delivered by an experienced production man. Afterward the meeting is thrown open to discussion of the material set forth in the text, and problems which may be peculiar to any particular branch of work in the plant. The subjects covered are teamwork, handling men, machinery and materials, organization, production records and management.

Beside a more thorough all-round knowledge of production methods, the course gives an opportunity for the leaders in the Press to get together, discuss important problems, not only among themselves, but with the higher executives, and to acquire at first hand the spirit of unity and team play which in the last analysis means the elimination of unrest.

Digitized by Google

Science and Mathematics in Terms of Human Welfare

GRUENBERG'S ELEMENTARY BIOLOGY

An introduction to the science of life, for beginning classes in the high school or junior high school. It points out the relation of biology to economics and sociology. It emphasizes life and action rather than formal biological classifications. It is a "new, safe and sane chart to guide the ship of life."

SCHORLING AND REEVE'S GENERAL MATHEMATICS

Composite mathematics, primarily for the first year of high school. The text covers the most significant principles of algebra, geometry, trigonometry, practical drawing, and arithmetic. It is revitalized and socialized mathematics which justifies its place in today's complex social and industrial life.

GINN AND COMPANY

Boston	New York	Chicago	London
Atlanta	Dallas	Columbus	San Francisco

BOOKS RECEIVED.

A First Book in Algebra, by Fletcher Durell, Lawrenceville School, and E. E. Arnold, Pelhams, N. Y., pages v+325+xxxix. 13×19 cm. Cloth. 1919. Charles E. Merrell Company, Chicago, Ill.

Div-A-Set, Division by letters, by W. H. Vail, Newark, N. J. 70 pages 12×20 cm. Paper. 50 cents. W. H. Vail, 141 Second Ave., Newark, N. J.

Illinois' State Geological Survey. Geology and Mineral Resources of the Hennepin and La Salle Quadrangles, by Gilbert H. Cachy. 136 pages. 17.5×26 cm. Cloth. 1919. The State Geological Survey, Urbana, Ill.

Brightness and Dullness in Children by Herbert Woodrow, University of Minnesota. 322 pages. 12.5×19 cm. Cloth. 1919. J. B. Lippincott Company, Philadelphia, Pa.

Publications of the United States Government:

Treasury Department Bulletin No. 41. The Place of Sex Education in Biology and General Science.

Department of the Interior Statement of the Commissioner of Education to the Secretary of the Interior for the Year Ending June 30, 1919.

Department of the Interior, Bureau of Education, Bulletin No. 28. 1919—Educational Periodicals During the Nineteenth Century. Bulletin No. 46. 1919—Bibliography of Home Economics. Bulletin No. 75. 1919—Monthly Record of Current Educational Publications. Bulletin No. 56. 1919—The Administration of Correspondence-Study Departments of Universities and Colleges. Bulletin No. 6. 1919—A Half-Time Mill School. Bulletin No. 74. 1919—Federal Executive Departments as sources of information for libraries. Bulletin No. 35. 1919—The Junior College. Bulletin No. 2. 1919—Standardization of Medical Inspection Facilities. Bulletin No. 71. 1919—Educational Directory, 1919-20, Part 4, Special Schools. Bulletin No. 68. 1919—Financial and Building Needs of the Schools of Lexington, Kentucky.

Digitized by Google

GYPSUM IN 1918.

The annual report on gypsum by the United States Geological Survey, Department of the Interior, has just been issued. This report contains statistics of production by States and by uses, imports, and exports, mention of the quantities of gypsum products used by Government organizations in housing operations for war use, a new description of the gypsum deposit in Florida, and lists of manufacturers of the principal gypsum products. A copy may be obtained free on application to the Director, United States Geological Survey, Washington, D. C.

GEOLOGY FURNISHES KEY TO THE CONSERVATION OF WATER.

The geologic history of the region furnishes the key to the conservation of its water supply. The sea has not always stood at the same level with reference to the land. In past geologic epochs it stood at different levels, and here from age to age it cut cliffs and terraces which are today the most conspicuous physical features of the coastal belt. In this belt there are several distinct terraces, the highest as much as 1,100 feet above the present sea level, and some of these terraces still bear well-preserved ancient beach ridges. But at some time in the geologic past the sea stood lower with reference to the land than it does today, and this fact has determined the quantity of water now stored in the ground in this region. When the sea stood lower or the land stood higher the streams that flowed from the mountains to the sea cut deep valleys into the coastal belt, and when the sea rose to its present level the streams quickly filled these valleys with porous deposits of gravel and sand, and these now form great subterranean reservoirs which hold the flood waters that are poured into them from the mountains.

BOOK REVIEWS.

The Blind, Their Condition, and the Work Being Done for Them in United States, by Harry Best. Pages xxviii+763. 13.5×20 cm. Cloth. 1919. Macmillan Company, New York City.

This book is without question one of the very best that has recently come from the printers, bearing upon the subject of the blind. The author is more than well versed in the subject and has brought together a mass of facts and data the like of which has never been compiled.

The book considers the blind with respect to the United States, almost entirely except as some of the causes for blindness may have been contributed by foreign countries.

The book is divided into seven parts. Part one is devoted to the general condition of the blind, part two, blindness and possibilities for its prevention, with six chapters, part three, provision for education of blind discussed in fourteen chapters, part four, intellectual provision for adult blind with four chapters, part five, material provision for the blind discussed in thirteen chapters, part six, organizations interested in the blind with three chapters, part seven conclusion, with respect to the work for the blind, one chapter. There are four appendices and a most complete index.

The author makes very profuse use of all articles and books with information bearing upon this subject, mention and reference being made to the various sources. Until comparatively recently the attitude of society toward the blind has been chiefly one of compassion, but if this work can be circulated among our influential men and women the country will be brought to a deep realization of the fact that strenous measures must be taken to reduce causes of blindness. C. H. S.

Digitized by Google

We Cover the Earth

Here is the list of countries to which SCHOOL SCIENCE AND MATHEMATICS goes each month:

Every State in the United States, every Province in Canada, Mexico, Cuba, Porto Rico, Brazil, Argentine, Chile, Peru, Ecuador; nearly every country in Europe (before the war every country); Egypt, Liberia, Cape Colony, The Transvaal, Persia, Ceylon, India, China Korea, Japan, Philippines, New Zealand, Australia, and Hawaii.

The only Journal in the English language devoted primarily to the needs of Science and Mathematics teachers in High Schools.

Remember this when deciding upon your subscription list of periodicals for Science and Mathematics.

This Journal is the only Journal whose pages are devoted to all phases of progressive Secondary Science and Mathematics Teaching.

Be a partner in this enterprise by investing $2.50 with it each year. Those teaching these subjects in Secondary Schools who wish to be progressive should be subscribers to this Journal.

During the last ten years it has accomplished more in placing Science and Mathematics teaching on its present high plane than any other agency.

Wide awake Mathematics teachers should have it to keep abreast of the times. Progressive Science teachers should read it to keep themselves alive in their subjects.

The best instructors in any subject are those broad enough in their pedagogical views to have a knowledge of what those in other subjects are doing.

SCHOOL SCIENCE AND MATHEMATICS is the only Journal through which you can receive this knowledge.

School Science and Mathematics

2059 East 72nd Place

CHICAGO, ILL.

Digitized by Google

Teaching Home Economics, by Anna M. Cooley, Cora Winchell, Wilhelmina H. Spohr, and Josephine A. Marshall, Teachers College, Columbia University, New York City. Pages vii+555. 13.5×20 cm. Cloth. 1919. $1.80. Macmillan Company, New York City.

The fundamental purpose of this book is to offer suggestions for the organization, administration, and teaching of all subjects bearing on Home Economics and with this thought in mind the authors have endeavored to adapt it to the needs of all classes of people whose needs they hope to serve. There is no question at this day and age of what every girl should know, her education should be devoted considerably to the subject of Home Economics. She needs this because she should know how to be able to live a more healthful life, rear her children intelligently, and serve her community.

This book is intended primarily to be used as a text in normal schools and colleges. It is divided into five parts. Part one, being devoted to Home Economics as a recognized study in the school program, five splendid chapters discussing this; part two, Courses in Study in Home Economics being thoroughly discussed in five chapters; part three, Lessons in Home Economics, the matter being presented in four complete chapters; part four, personal materials and opportunities in teaching Home Ecomics, the matter being clearly presented in four chapters; part five, is an addenda of various kinds. There is also a very complete index of nine double-columned pages.

The book is splendidly written and will make good reading for the laywoman. A splendid bibliography is given too. Many chapters close with suggestions for review and references for further reading. Every Home Economics teacher in the country should possess a copy. C. H. S.

Applied Science for Wood Workers by Wm. H. Dooley, Principal of North Textile School, New York City. Pages x+457. 13×19 cm. Cloth. 1919. The Ronald Press Company, New York City.

This book is a companion volume of the "Metal Working Trades." There is no question but what every mechanic or tradesman should be trained as thoroughly as possible in the handicraft of his trade. But if he is to be a skilled worker he should have considerable knowledge of the scientific principles involved and should know the reasons why certain operations in his trade should take place. Knowledge can be secured, however, by him in becoming conversant with good texts, such as this one. The knowledge here gained with his experience will enable him to be a better and more efficient workman.

The book is of such nature and character that it is well adapted for teachers in secondary and technical schools and by science teachers in the vocational schools. It is splendidly written, clear, and to the point. There are thirty-five chapters, each of which not only begin with bold face type but give the reader an idea of what is discussed in it. Each chapter closes with a splendid list of suggested questions. There are two hundred and six drawings and views, all splendidly executed. All persons interested in wood should have a copy of this most valuable book. C. H. S.

Applied Science for Metal Workers by Wm H. Dooley, Principal of North Textile School, New York City. Pages x+479. 13×19 cm. Cloth. 1919.

All that has been said with reference to the book "Applied Science for Wood Workers" is true of this book. It deserves a large sale. Every metal worker should possess a copy. C. H. S.

Digitized by Google

Spencer Scientific Instruments

Whether

MICROSCOPES, MICROTOMES OR DELINEASCOPES

MAKE AN INSTINCTIVE APPEAL

TO THE LABORATORY WORKER

IT isn't only their accuracy and utility. It's something in the finish, even more in the design, but in addition to all these, it is those little things—clever little devices, which accomplish the same end but in a better way—exactly the way that the laboratory worker wants them. These are the distinctive features of Spencer instruments, made distinctive because our designers, experienced laboratory workers, possess the laboratory view point.

SPENCER MICROSCOPE No. 64

has become a standard for high school and college general laboratory work. It's distinctive in that it has a side-fine adjustment which will not show lost motion with use because there are 34 threads of the screw always engaged instead of but *one* as in other makes. It has other advantages.

Send for 1920 Catalog

Spencer Microscope
No. 64B—$53.25
Discount to Schools

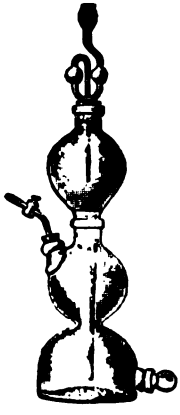
SPENCER BUFFALO U.S.A.

SPENCER LENS COMPANY

Buffalo, New York

Manufacturers of **Microscopes, Microtomes, Delineascopes, Optical Glass, Scientific Apparatus, Etc.**

SPENCER BUFFALO U.S.A.



No. 2402

We Carry a Complete Stock of

Chemicals & Apparatus

for the

Physical

Agricultural

Chemical

Biological

Laboratory

We Excel in Equipping High School Laboratories.
Let Us Quote Prices on Your Next List of Requirements.

THE KAUFFMAN-LATTIMER CO.

41 East Chestnut Street

Columbus, Ohio

Digitized by Google

Principal of Agriculture for High Schools, by John H. Gehrs, Normal School, Cape Girardeau, Mo. Pages x+594. 13.5×19 cm. Cloth. 1919. $2.25. Macmillan Company, New York City.

The fundamental purpose of this text is to demonstrate how agricultural production may be increased. As all students of this subject know, the products of the farm have not kept pace with the increase in population. This is an important factor which has helped to increase the cost of living. The influence of books of this character on our farming population and those interested in this subject will surely assist in increasing the products of the soil and thus reducing the price of food stuff. Every farmer should study his farm soil thus determining what crops he should raise in order to give him increased returns.

The book is divided into five sections. Section one is devoted to farm crops where major crops are discussed, section two, to farm animals, and here the matter is thoroughly dealt with; section three, devoted to soils, and is a splendid discussion of them; section four, devoted to horticulture; and section five, farm management; this is an important phase of the work as there are already too many farmers who have very little conception of what real farm management is. Nearly every chapter finishes with a set of pertinent questions.

The book makes interesting reading to any man or woman who is a lover of the country. There are over two hundred drawings and halftones in the text. C. H. S.

A Handbook of American Private Schools, and Annual Survey 5th edition, by Porter Sargent. Pages 768. 13×8.5 cm. Cloth. 1919. Porter Sargent, 14 Bacon St., Boston.

There is not space enough to write an eulogy or a review of this splendid book, too much cannot be said concerning its real worth. It is an encyclopaedia on the private schools of the United States and Canada, and anyone wanting information concerning almost any private school in these two countries will find it given in this volume. Parents contemplating sending their children away to school, if they desire a private school, can secure no better information than by referring to this book. All schools should have a copy of the book in their libraries. The author should surely be congratulated on the splendid volume he has put out. C. H. S.

Engineering Application of Higher Mathematics, by V. Karapeloff, Cornell University. Four parts, all 14×21 cm. Cloth. 75c each. Part I pages v+101, part II pages v+112, part III pages v+79, part IV pages vi+64. John Wiley and Sons, New York City.

These four books although they do not contemplate an exhausted treatment of the subject are complete within themselves. The matter is handled in a most interesting way and to the student who has had previous mathematical training, therefore is equipped for this kind of work, will find in these four volumes matter which will be of the greatest help to him. The topics treated are typical in engineering work. The drawings are extraordinarily clear and well made. Throughout the body of the books numerous problems are given. The books were primarily for use in engineering schools. All engineering students and instructors would do well to possess copies. C. H. S.

Examples in Magnetism, by F. E. Austin. Pages 90. 12×19cm. Leather. 1916. F. E. Austin, Hanover, New Hampshire.

A splendid little hand book for laboratory work in magnetism for secondary schools. Contains many examples and many exercises as well as questions upon magnetism. A little text that all Physics teachers should possess. C. H. S.

Digitized by Google

515.05
S37
54

Vol. XX. No. 3 Whole No. 167

MARCH, 1920

SCHOOL SCIENCE AND MATHEMATICS

A Journal for All Science and Mathematics Teachers

Central Association Number

Founded by C. E. Linebarger

SMITH & TURTON, Publishers

Publication Office, Mount Morris, Illinois

CHICAGO OFFICE, 2059 East 72nd Place, CHICAGO, ILL.

CHARLES H. SMITH
EDITOR
Hyde Park High School, Chicago

CHARLES M. TURTON
BUSINESS MANAGER
Bowen High School, Chicago

DEPARTMENTAL EDITORS

Agriculture—Aretas W. Nolan
The University of Illinois, Urbana, Ill.
Astronomy—George W. Myers
The University of Chicago
Biology, Research in—Homer C. Sampson
The Ohio State University, Columbus
Botany—Wonolo Whitney
Hyde Park High School, Chicago
Chemistry—Frank B. Wade
Shortridge High School, Indianapolis, Ind.
Chemistry, Research in—B. S. Hopkins
The University of Illinois, Urbana, Ill.
Earth Science—William M. Gregory
Normal Training School, Cleveland, Ohio
General Science—Fredric D. Barber
State Normal University, Normal, Ill.
Mathematics—Herbert E. Cobb
Lewis Institute, Chicago
Mathematics Problems—Jasper O. Hassler
Crane Technical High School and Junior College, Chicago
Physics—Willis E. Tower
Englewood High School, Chicago
Physics, Research in—Homer L. Dodge
The State University of Oklahoma, at Norman. Representing American Physical Society
Science Questions—Franklin T. Jones
Warner and Swasey Co., Cleveland, Ohio
Zoology—Harold B. Shinn
Schurz High School, Chicago

Published Monthly October to June, Inclusive, at Mount Morris, Illinois
Price, $2.50 Per Year; 30 Cents Per Copy

Entered as second-class matter March 1, 1913, at the Post Office at Mount Morris, Illinois, under the of March 3, 1879

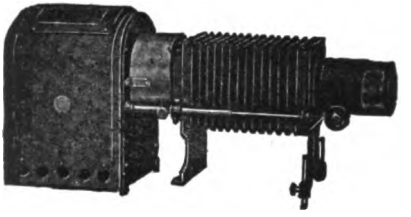
Digitized by Google

"McIntosh Lanterns Are Honest Lanterns."

Lantern Slides of Science

A copy of our Catalogs of science slides w[illegible] when published to every member of the Central Association. Are you a member? Did you get your copy? Did you keep it?

If not, there is another copy for you if you are interested. Just write us a card and ask for it. No obligation. You'll need it in placing your orders for science slides.



Lanterns from $36.00 up. Opaque and micro projectors, slides and accessories.

McINTOSH STEREOPTICON COMPANY
410 Atlas Block, CHICAGO, ILL.

For Next Semester

Moore and Halligan—PLANT PRODUCTION
—Agronomy and Horticulture

Mayne and Hatch—HIGH SCHOOL AGRICULTURE
—General Treatment

Coulter—PLANT LIFE AND PLANT USES
—Practical Botany—Not too Technical

Hunter—CIVIC BIOLOGY
—Community Welfare

Dryer—HIGH SCHOOL GEOGRAPHY
—Physical—Economic—Regional

Clark—INTRODUCTION TO SCIENCE
—A real general science.

New York
Chicago
Cincinnati
Boston
Atlanta

AMERICAN BOOK COMPANY
330 East Twenty-second Street
CHICAGO, ILLINOIS

Digitized by Google

SCHOOL SCIENCE AND MATHEMATICS

VOL. XX, No. 3 MARCH, 1920 WHOLE No. 167

SOME EVERYDAY APPLICATIONS OF ACOUSTICAL PRINCIPLES.[1]

BY F. R. WATSON,

University of Illinois, Urbana.

One of the everyday axioms concerning fishing is not to talk. "Don't talk or you'll scare the fish" is the usual statement. This caution is well founded because when people talk, experience shows that the fish become scared. They become frightened, however, for a different reason than the one assigned.

Theory shows conclusively that sounds generated in the air are reflected almost totally when they reach a surface of water, so that little likelihood exists that any appreciable amount of the sound produced by talking enters the water. Search must be made further for the cause of the fright of the fish. The explanation is found in the action of the sounds set up in the structure of the boat that contains the fisherman. Thus, the scraping of feet, the rattling of oars or other objects creates a disturbance that passes easily through the boat into the water with very little loss of intensity.

The explanation is now quite simple. When a fisherman talks, he usually moves about somehwhat to relieve the physical strain of sitting still. This bodily movement is likely to set up some disturbance in the boat, and this latter action is what disturbs the fish. The writer has verified this theory by experiment. Sitting still in a boat and talking loudly produced no effect on the fish, but the slightest scraping of the feet on the bottom of the boat sent the fish rapidly away. A further confirmation has been given to the writer by a man who has witnessed the hunting of whales in Arctic waters. Success in getting close to the whale is attained only by observing the greatest precautions to avoid generating sounds in the water. Either the boat is propelled by

[1]Read before the Physics Section meeting of the Central Association of Science and Mathematics Teachers at Lake View High School, Chicago, November 29, 1919.

Digitized by Google

sails with suitable silencing of the yard arms, or by rowing, in which case the oar locks are muffled and the sailors' shoes are wrapped in cloths to prevent accidental scuffling. At the same time, all of the persons in the boat may talk as much as they please.

The principle just described furnishes the explanation for another everyday phenomenon; namely, the insulation of sound in buildings. When a sound travels through the air to a plaster wall of some thickness, it is almost totally reflected. Calculations show that only about three parts in a million of the incident sound get through a solid plaster wall 2½ inches thick. Such sounds would be generated by the voice, a violin, etc. In case, however, the source of sound makes an intimate contact with the building structure as, for example, a piano resting on the floor, the vibrations will travel with ease through the continuity of structure and may appear surprisingly audible at some distant point in the building where a resonant surface transmits the vibrations to the air.

Sound is a wave motion and is subject to the general laws of wave motion. It progresses with small loss in intensity in a homogeneous medium, but on encountering a second medium differing in density or elasticity, it suffers a partial reflection and refraction, the relative amounts of which are proportional to the abruptness of change of elasticity and density. For instance, referring again to the insulation of sound in buildings, it is found that sounds generated in air will travel almost unchanged as long as the medium remains unchanged. A sound generated in a room passes easily to other rooms and distant points in a building through ventilation ducts, open doors and halls, or generally, wherever a continuous air passage is presented. On meeting an obstacle, however, the sound is hindered in its progress as already explained for the case of a plaster wall.

When an air passage becomes narrow, a new phenomenon appears in the creation of a friction between the walls of the passage and the vibrating air particles that propagate the sound. This friction transforms the sound energy into heat. According to this reasoning, a wall crack will not transmit much sound. If the wall is fairly thick, sound entering one side in a crack will be damped out by friction before passing through. The crack or aperture must have some area of cross section to allow transmission. This statement may be verified by noting the increase in sound when a window is opened suddenly as a street car or other noisy vehicle passes by. Closing the door to a room where

Digitized by Google

a typewriter is sounding will show a corresponding reduction of sound.

This action of friction has other applications. The efficiency of hair felt as a sound deadener in auditoriums is due largely to the friction generated in its pores. Calcualtions show that a layer of hair felt 10.4 inches thick will completely extinguish a sound of average intensity and thus allow none to be transmitted. A heavy rug because of the interstices between its fibres will set up a similar friction for sound waves and for this reason possesses a considerable deadening effect. The writer has calculated the amount of heat generated in an ordinary rug three feet by five feet in area when the sound of an average speaker falls upon it for thirty minutes. This gave the value .00001 calorie, indicating that the energy of sound is quite small.

Another question might be asked in this connection concerning the ultimate fate of sounds that proceed upward. The answer is found again in the action of friction, because the sound is stifled in attenuated air in the upper reaches of the atmosphere.

A further action of sound that produces many phenomena of everyday occurrence is diffraction. We read in textbooks that a train of waves proceeding through a narrow aperture will be spread out as if coming from a new source of waves. An open window illustrates this action. The window is a narrow opening for many outside sounds because these may be heard in all parts of a room, thus indicating a diffraction or spreading of the sound as it enters. The action is modified somewhat by the reflection of sound from the walls of the room.

If the aperture is wide compared with the wave length, it produces but little effect on the waves and they progress almost unchanged. Following experiments suggested by Lord Rayleigh[2] the writer[3] has developed a megaphone with a rectangular aperture. Speech waves emerging from this megaphone are spread sideways by the narrow dimension, but scarcely affected by the wide dimension as shown in Figures 1 and 2. The diffraction is further illustrated in Figure 3 where circular water waves proceed simultaneously through a narrow and a wide aperture.

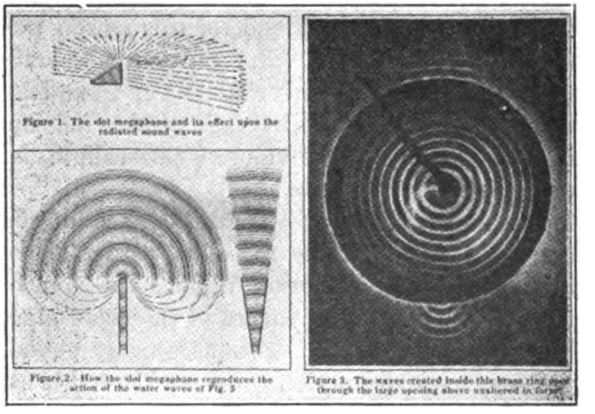
This megaphone is useful in a number of situations. Of particular interest to educational institutions, it may be used to address a crowd of people on bleachers at an athletic meet. It has an advantage over the usual cone shaped megaphone. The latter instrument directs sound to a favored few on the line of

[2] *Philosophical Magazine*, Vol. 6, page 289, 1903.
[3] *Physical Review*, Vol. 11, page 244, 1918.
Scientific American, May 24, 1919.

Digitized by Google

its axis, while the rectangular megaphone spreads the sounds into a fan shaped zone that reaches all the auditors on a set of ordinary bleachers.

The action of the megaphone is reciprocal, that is, it may be used as a selective receiver. Sounds of sufficient intensity generated in the fan shaped zone just described will be heard by the ear placed at the small end of the megaphone, while sounds



outside this zone will not be so received. This receiving action allows a systematic search of the sky to be made for airplanes. The megaphone has other uses, but enough has been given to illustrate its action.

In conclusion, a statement should be made concerning the choice of illustrations in this discussion. They were chosen with the hope that they might be of some use in teaching the subject of sound and also, that they might stimulate efforts to explain other every-day phenomena by scientific principles.

SIX THOUSAND TONS OF ARSENIC.

The white arsenic produced in the United States in 1918 amounted to 6,323 short tons, valued at $1,213,000. By far the greater part of the domestic white arsenic consumed in the United States in 1918 was used in preparing insecticides and weed killers, the total quantity so used in 1918 being about 2,000,000 pounds, according to the United States Geological Survey, Department of the Interior. Nearly 1,000,000 pounds was used in the glass industry, and a small quantity in the preparation of drugs.

The production of gold, silver, copper, and lead in South Dakota and Wyoming during the year 1918 is reported by Mr. Charles W. Henderson, in a publication recently issued by the United States Geological Survey, Department of the Interior. This report, which is a chapter of the Geological Survey's volume on "Mineral Resources of the United States, 1918," reviews briefly the situation in the producing counties of these states and records significant new developments. A copy can be obtained from the Director, United States Geological Survey, Washington, D. C.

Digitized by Google

THE AUTOMOBILE IN PHYSICS.[1]

By H. C. Krenerick,

North Division High School, Milwaukee, Wis.

The content of physics is constantly changing. The physics teacher, as no other, has the ever present task of keeping up with the times. Our textbooks and textbook writers are too conservative. Never before have we had an invention or physical appliance so universally used, so composite of physical principles, as the automobile, and yet practically all textbooks in use make no mention of that worthy institution.

Whenever new subject matter is suggested, the objection always raised is that there is no time, that the course is already overcrowded. The conclusive answer to such objections is that there is always room for the most essential things. We still find in our modern texts cuts and discussions of drum and ring wound armatures, unipolar and multipolar dynamos, Westinghouse air brakes, hydraulic rams and elevators. But what part of our boys and girls ever come in contact with them? Compare the interest and instructive value of such applications with those found in the automobile. Practically every principle we teach in heat and electricity finds its application in the modern automobile.

For the first few years of my efforts to use the automobile as a source of application of the principles of physics, I depended on lantern slides of cuts and diagrams. But these were inadequate in some cases compared with the real thing. Two years ago, I included in my requisition for supplies an old incapacitated automobile, to be purchased when I found one suitable for my purpose. The intention was to remove the body, take apart the chassis, thoroughly clean and reassemble it in my laboratory. Not much floor space was available, so a small car was necessary. It was essential also that it be somewhat modern in its improvements.

The country had just entered the war, automobile manufacturing was soon limited and any old car was in demand for some kind of service. I went the rounds of the auto wrecking establishments and second-hand dealers many times, advertised in papers, interviewed automobile dealers, and argued that it would be most excellent advertising. They admitted that it would and promised to keep the matter in mind. The "Want and Ad" columns of the papers were always searched and after many

[1]Read before the Physics Section of the Central Association of Science and Mathematics Teachers at Lake View High School, Chicago, November 28, 1919.

Digitized by Google

months the opportunity finally came. The last of September I was able to get a Monroe roadster, 1917 model, a complete and modern car in practically every respect.

With the aid of a couple of boys on Saturdays the body of the car was removed, the chassis completely dissembled and cleaned. Before reassembling the chassis in the laboratory, many parts of the castings and housings were cut away that the working mechanism of all parts might be revealed. Originally, I had no thought of cutting away the parts by hand, but after a few unsuccessful attempts to have it done at some machine shop, I tried a hack saw. I was glad to be able to do it so easily by hand. It took a good many hours' work, but it is more extensively cut away and more to my satisfaction than had it been done by a machinist.

I have a few slides of the chassis as it is now set up in my laboratory. They do not do it justice, however, I would need color photography to bring out the different colored paints used. The different colors were used for an instructive rather than decorative purpose. The entire gasoline system, including the tank, carburetor, intake manifold, intake valves and rods are painted red. The exhaust valves, rods, mainfold and muffler are yellow. The water passages and radiator are blue. The same color plan is used as an aid in tracing the electric circuits. The starter circuit wires are painted black; the charging circuit is blue; the primary circuit is yellow; the secondary circuit is red.

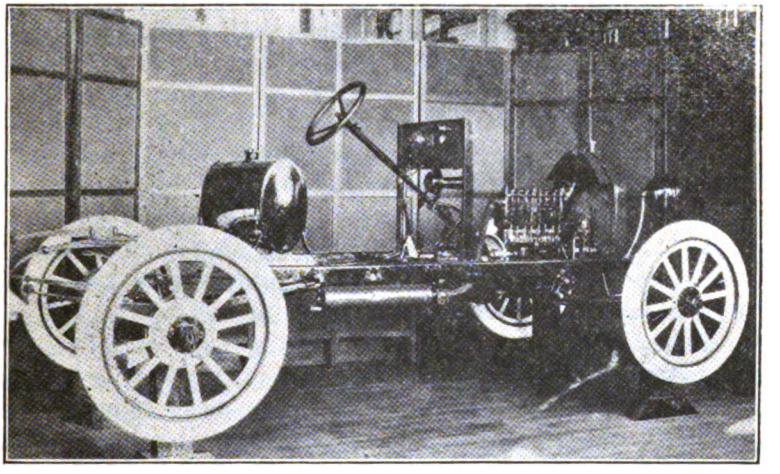
Castings and housings have been cut away so that the pistons, valves, cam shaft, crank shaft, clutch, gear set, driving shafts, roller bearings and differential are seen in action. The wheels are supported from the floor so that all of the mechanism may be kept running by means of the storage battery and starter. Steering gears and the internal expanding brakes have also been exposed by cutting away parts of the housing. All parts are thoroughly cleaned and can be easily taken apart or assembled for class-room study or demonstration.

At least three laboratory exercises will be given on the chassis. One experiment will be to trace and diagram the electric system. With the different circuits in different colors, this will not be a very difficult task. Fortunately, the system used on this particular car is the Connecticut Autolite, one of the most simple used.

A second experiment will be to determine the horse power of

Digitized by Google

the engine by the S. A. E. rating (H. P. = $D^2N/2.5$). Also by the complete formula: H. P. = $(P \cdot A \cdot S \cdot N \cdot E)/(4 \times 33{,}000)$. Assuming, as is claimed, that the engine is most efficient at 2,400 revolutions per minute, find the piston speed (S) in feet per minute. The average pressure (P) is taken as 90 pounds to the square inch, and the efficiency of transmission (E) as 75 per cent. In this experiment the cylinder head with its valves, etc., will be removed and later assembled by the student.



A third experiment will be to apply the principle of the wheel and axle to the various gear wheels in the transmission from crank shaft to rear axle, and determine the gear ratio of the different speeds. From these results and the circumference of the rear wheel, determine the speed of the car in miles per hour at which the engine will be at its maximum efficiency, 2,400 revolutions per minute. Also with a pressure of 90 pounds to the square inch, and a transmission efficiency of 75 per cent, find the maximum road resistance at rear wheels.

After our textbook study of the steam engine, I like very much to spend a day or more on the steam automobile because of the interesting and excellent illustration of many of the principles of heat. A set of twelve slides was made from cuts and diagrams obtained from the Stanley Automobile Company. The complete condensing system used on the latest model, the various automatic controls working on some principle of heat, the different fuel systems, the type and construction of the boiler, the double action engine, the simple illustration of the eccentric reversing mechanism, the comparative ease of control, all make it a very interesting and profitable study.

Digitized by Google

CHEMICAL WARFARE SERVICE AND CHEMICAL TEACHING.

By William McPherson,

Ohio State University, Columbus, Ohio.

I propose to discuss the subject assigned me by your program committee under two heads. In the first place I will give a brief account of the work carried on by the Chemical Warfare Service, or rather, since the time is limited, with that part of it with which I am most familiar; and in the second place I will endeavor to point out how the experiences as well as the achievements of chemists during the war should influence for good the teaching of chemistry in our schools and colleges.

I. The Work of The Chemical Warfare Service.

The organization of Chemical Warfare Service as a separate branch of military service was the culmination of an effort to utilize, in the most effective way, the services of the trained chemists of our country in the winning of the war. This branch of the army had to do largely with the production of poison gas and the means of combating it. It also rendered services in many other lines of work, such as in the investigation of certain chemical substances for the production of clouds and smoke screens. Incendiary bombs, rockets and flares also came within its province. My own connection with the Service was confined almost entirely to the production of toxic gas and my remarks therefore will be confined largely to this phase of the work.

The first gas attack in the great war was launched by the Germans on April 22, 1915. The story is well known and need not be repeated here. Nearly two years elapsed between the date of this first attack and that of the declaration of war by the United States. Unfortunately, but little attention was given to this new method of warfare in our country during this interval. When we finally entered the war, gas warfare was on a thoroughly established basis. The War Department therefore was immediately faced with all the problems connected with its development. Suitable gas masks had to be made in large quantities. Methods for the production of toxic gas on a large scale had to be worked out and put into operation. Gas shell as well as the necessary machinery for filling these shell with the toxic materials had to be developed—all at the earliest possible moment. The enormity of the problems was foreseen. Gases, the preparation

[1]Read before the Chemistry Section of the Central Association of Science and Mathematics Teachers at Lake View High School, Chicago, November 29, 1919.

Digitized by Google

of which even in small quantities was prohibited in many laboratories, because of the danger incident to this preparation, were now to be manufactured in quantities of many tons daily, loaded into shell and shipped to our armies in France.

At this time the War Department did not have available the personnel and facilities for even carrying on the research work necessary for the development of gas warfare. The only laboratories at all adapted for this sort of work were those connected with the different arsenals, and these were already overcrowded with work connected with the problems of the arsenals. In February, 1917, two months before the United States declared war, the Bureau of Mines, anticipating the declaration of war and cognizant of the fact that the experiences gained by the Bureau in an extended study of mine gases would be of value in the investigation of this larger question, offered its services to the War Department. Later this offer was accepted and to this Bureau was assigned the task of carrying on the necessary research work. The production of toxic gas and the filling of this into shell were assigned to the Trench Warfare Section of the Ordnance Department. The research work originally assigned to the Bureau of Mines, the production of toxic gas and the loading of this into shell, as well as the production of gas masks, were all combined finally into the Chemical Warfare Service as a separate unit of the National Army.

It was the original intention to interest existing chemical firms in the manufacture of the required toxic materials, with the hope of obtaining from such firms the entire supply required. As the work developed, however, difficulties arose in carrying out this program. The manufacture of such material at private plants necessitated its shipment to the United States filling plant for filling into shell, and the transportation of large quantities of highly toxic gases would naturally be attended with great danger. After due consideration, the Director-General of Railroads ruled that all such shipments must be made by special train movements—a very expensive method of transportation. Still more serious objections, however, were encountered in the efforts to enlist the cooperation of existing firms. It was recognized by these firms that the manufacture of such materials would be attended by very great danger; that the work would be limited to the duration of the war; and that the processes involved, as well as the plants necessary for carrying out these processes,

Digitized by Google

would have little post-war value. Moreover, such firms as had the personnel and equipment for carrying on this kind of work were already overcrowded with orders; with few exceptions, therefore, they were unwilling to undertake work of this character.

As soon as it became evident that the necessary supplies of toxic gas could not be obtained in whole from existing firms, it was decided to build certain Government chemical plants. The question of their location had to be answered immediately. The Government had recently taken over a large tract of land near Edgewood, Maryland, about twenty-five miles out of Baltimore on the main line of the Pennsylvania Railroad running between Baltimore and Philadelphia, as a proving ground. A part of this tract (about 3,400 acres) had already been set aside as the location of the U. S. Filling Plant which was being built for the purpose of loading toxic materials into shell. It was recognized at once that this was an ideal place for the building of at least some of the chemical plants, thus avoiding the shipment of the toxic materials; accordingly, by December 1, 1917, it had been definitely decided to build at Edgewood two plants—one for the production of chlorpicrin and one for the production of phosgene. Later the U. S. Filling Plant became known as Edgewood Arsenal, and here was developed an enormous death-dealing industry. In addition to the Government plants at Edgewood other Government gas plants were located at Buffalo, Niagara Falls, Kingsport, Tenn., Stamford, Conn., Hastings-on-Hudson, N. Y., Midland, Mich., and Bound Brook, N. J. The choice of location was based primarily on availability of facilities at the places designated.

Since it is impossible to go into detail in regard to the subject, I will briefly review the projects carried out or in process of completion at the time of the signing of the armistice.

(*a*) *The Production of Chlorine.* Chlorine is the chief of all materials used in the manufacture of toxic gas. It bears the same relation to the manufacture of toxic gas that nitric acid does to the manufacture of explosives. It was not only used directly in wave attacks, but it is a constituent of nearly all toxic gas. Fortunately, chlorine had long been used in the United States and its manufacture was on a thoroughly established basis before war was declared. The pre-war production was close to five hundred tons daily, most of which was used in making "bleach." It soon became evident that large additions would have to be

Digitized by Google

made to the chlorine output in order to meet the gas requirements. After a thorough study of the problems involved, it was decided to build a plant at Edgewood, with a capacity of one hundred tons daily. The cell used (Nelson) in the plant is operated by a current of 1,000 amperes and 3.8 volt and has a capacity of 60 pounds of chlorine and 65 pounds of caustic soda per twenty-four hours. The current required for electrolyzing the salt was obtained partly from the hydro-electric plant at McCall's Ferry, Pa., and partly from local generators. Construction on the plant began on May 11, 1918, and the first unit was ready for operation on August 1 of the same year.

(*b*) *Chlorpicrin* (CNO_2Cl_3). This compound (boiling point 112°) is made by passing live steam through a mixture of bleach and picric acid. It was the first of the toxic materials to be produced in the United States on a large scale. The Government had two plants; one at Stamford, Conn., and one at Edgewood. The former came into production first, a shipment of over 100,000 pounds being made from this plant on March 11, 1918. When the armistice was signed these two plants had a monthly capacity of 3,000,000 pounds. There was actually produced 5,552,000 pounds, of which amount 3,806,000 pounds were shipped overseas.

It should be noted here that the chemical plants of the Arsenal were never operated at full capacity, and indeed were often shut down because of lack of shell. The largest part sent overseas was shipped stored in large drums and filled into shell obtained from our Allies.

(*c*) *Phosgene* ($COCl_2$). This gas (boiling point 8°) is made by passing a mixture of chlorine and carbon monoxide in molecular proportion over some form of porous carbon which acts as a catalytic agent. The Government had three plants for its manufacture ,one at Niagara Falls, in connection with the phosphorus plant of the Oldbury Electro-chemical Company, one at Bound Brook, N. J., and one at Edgewood. The process of production in these three plants differed in detail only in the method of producing the carbon monoxide. In the Niagara Falls plant, the carbon monoxide was obtained as a by-product in the manufacture of phosphorus, at the Bound Brook plant it was made by passing oxygen over carbon, while at the Edgewood plant it was produced in large quantities by passing a mixture of oxygen and carbon dioxide over carbon. The total production of phosgene at these plants up to the date of the signing of the

Digitized by Google

armistice was 3,233,070 pounds, of which amount 840,000 pounds were shipped overseas. The monthly capacity of the three plants on November 11, 1918, was 2,100,000 pounds, and enlargements were nearly completed which would have increased the capacity to 3,300,000 pounds by January 1, 1919.

(*d*) *Bromine.* This element is essential to the production of that type of gases known as lachrymators or tear producers. The pre-war production of this substance was limited, amounting to less than 1,500,000 pounds annually, about two-thirds of which was produced by the Dow Chemical Company of Midland, Mich. This supply was entirely inadequate for war purposes. It was decided, therefore, to enlarge the supply and inasmuch as the richest bromine bearing brines are found near Midland, Mich., a contract was made with the Dow Chemical Company to sink seventeen wells and separate the bromine from the resulting brine. This work was completed and the wells are now the property of the Government and are capable of producing 650,000 pounds of bromine annually, or nearly one-half of the pre-war production.

(*e*) *Dichlorethyl sulphide* $(C_2H_4Cl)_2S$, commonly known as mustard gas. This compound when pure is a colorless or slightly yellow oily liquid boiling above 200°. It was first used by the Germans in 1917. Later it was recognized to be of the greatest importance and every effort was made by the Allies as well as the central powers to manufacture it in large quantities.

The Government constructed three mustard gas plants as follows: (*a*) One at Buffalo in connection with the National Aniline and Chemical Company; (*b*) one at Hastings-on-Hudson, in connection with the plant of Zinnser and Company; and (*c*) one at Edgewood.

Only the latter came into production by the time of the signing of the armistice, although the other two were practically completed. There was made at this plant 1,422,000 pounds, and of this amount 380,000 pounds had been shipped overseas. The total monthly producing capacity of the Government plants on November 11 was 1,800,000 pounds or three times that of the German plants. By January 1, 1919, had the war continued, the Government plants could have produced 8,000,000 pounds monthly.

(*f*) *Brombenzylcyanide* ($C_6H_5CHBrCN$). This compound when pure is a white crystalline substance, melting at 29°. It is by far the best lachrymator known. The Government built a

Digitized by Google

plant for its production at Kingsport, Tenn. This plant was completed and production began a few days before the signing of the armistice. It had a monthly capacity of 180,000 pounds.

(*g*) *Diphenyl chlorarsine* ($C_6H_5)_2AsCl$). This is a white crystalline solid melting at 44°. It is the most effective of the gases known as sternutators, or sneeze producers. Its effectiveness depends upon the fact that, when in a finely divided state, it readily passes through the gas masks and causes violent sneezing. This necessitates the removal of the masks, thus subjecting the troops to the effects of poisonous gases used along with the diphenyl chlorarsine. The Government had begun the construction of a large plant for the manufacture of this compound, but the work of construction had not progressed far when it was stopped because of the armistice.

A little contemplation will suffice to make one realize the difficult problems involved in the filling of shell with poisonous materials. It was essential that the work be done automatically and that the necessary machinery be placed in well ventilated tunnels, so arranged that the filling machinery could be operated from the outside—thus insuring safety to those engaged in the operation. It is only possible at this time to say that the necessary machinery for the work was invented and built and proved to be satisfactory for the work at hand.

The above projects were the main ones carried on under the supervision of the Production Division of Chemical Warfare Service. In addition to these, however, this Division was in charge of numerous other projects of a less extensive and difficult character.

II. The Effect of the War Upon the Teaching of Chemistry in Our Schools and Colleges.

During the interval that elapsed between the date of the beginning of the war and that of the entry of the United States into the struggle, even the most superficial observers could not fail to recognize the part chemistry was playing in the prosecution of the war. In many respects the contest was a chemical one in which the chemists of the opposing powers were measuring their wits against each other. England and France at first failed to recognize this fact, and many of their chemists joined the front line ranks. Later these men were called back to the research laboratories and chemical plants, but not until many lives had been needlessly sacrificed. When the United States entered the war every effort was made to avoid the mistakes

Digitized by Google

made by our Allies and to utilize the services of our chemists in places where their work would count for the most. As a result, no less than 4,000 chemists (Secretary Parsons of the American Chemical Society gives the number as 4,003) were known to be in military service on chemical assignment. No members of any profession responded more willingly to the call. From the classroom, the laboratory and the factory, chemists responded, and all through the war concentrated their tireless energy upon the solution of problems that were of vital importance to the winning of the great struggle. Included in this group of workers was a large percentage of teachers of chemistry in our schools and colleges. When the armistice was signed and demobilization came, these teachers, as a rule, returned to their classrooms and laboratories; but in many respects they were different persons from those who had responded to the call. Their experiences had developed in them new traits or augmentation of old ones that were certain to make their work as teachers more effective. Among these traits I shall mention the following:

(*a*) *Self-confidence.* No one has less regard for the blatant egotist than I. But there is a difference between the loud and generally poorly trained egotist and the individual who has that self-confidence and assurance in his own ability to accomplish important tasks. How often do we see persons who may have only a mediocre training but who believe in their own ability to accomplish results, surpass their more brilliant associates who lack this faith in their own ability. It has often seemed to me that teachers, more than any other class, lack this self-confidence. Perhaps this is due primarily to the reflection of the public mind; for I think it is true that teachers as a rule have been regarded by the public as impracticable, theoretical, bookworms. The public said as much, and we came to believe the statements—much as we came to believe the Germans when they kept telling us that we could not do certain things—make dyes for example—or as many people still believe that our dyes are inferior to those of German manufacture. But all this has been changed—largely as a result of the war. The teachers suddenly found themselves face to face with problems upon whose solution the lives of our soldiers hung. Into this work they flung themselves with all their energy. The results accomplished brought them confidence in themselves, confidence in their ability to do things, and now when the war is over and they have returned to their former duties, this re-

Digitized by Google

newed confidence cannot fail to make their work as teachers more effective.

(*b*) *Enthusiasm.* It has seemed to me that whenever I come in contact with any teacher who has done his bit in winning the war, that I have found a man or woman, (for the women certainly did their share) who has become more enthusiastic as a result of this experience. This is quite natural, for association with other workers in a tireless effort to be of service, breeds enthusiasm. Now it is entirely unnecessary for me to discuss here the part that the spirit of enthusiasm plays in a teacher's success. It is the catalytic agent, if you please, that arouses the student and incites him to activity and creates in him a desire to learn and to be a factor in the world's progress.

(*c*) *Preparedness.* It is self-evident that preparedness is fundamental to the success of every teacher. Enthusiasm without knowledge is a dangerous trait, and a teacher who is both enthusiastic and ignorant may do incalculable harm in our schools. I believe that as a class our teachers of chemistry are well trained, but of this I am certain, that no teacher passed through the experiences of war without adding greatly to his knowledge. Indeed, many, I am sure, learned more chemistry during the war than in any like period. Perhaps it was a different phase of chemistry—but this may have made it all the more valuable. Many found themselves working with the leaders of the science, and this intimate contact in helping to solve the problems presented opportunities for growth never before experienced.

(*d*) *Spirit of Work.* Many also learned the value of hard work. Night as well as day found them at their tasks. They learned to enjoy work as never before, and perhaps to their surprise they waxed and grew strong under the burdens.

(*e*) *The research Spirit.* If any one fact has been impressed upon the minds of the leaders of thought in our country, as a result of the war, it is the recognition of the part that research must play in the development of civilization. The story of the achievements during the war is largely a story of the solution of problems of all sorts and all of this work at least embodied the spirit of research. No intelligent person, the teacher least of all, could have passed through this experience without catching something of this spirit. Our teachers will return to their classrooms and laboratories with a new valuation of the part they can play in instilling into the minds of their students, something of this

Digitized by Google

spirit of inquiry which may lead many of their students ultimately to become potent factors in the world's progress.

I have already spoken of the different attitude of the public towards the teachers of chemistry. As a result, the college professor is no longer held up to ridicule for his absent-mindedness and impracticability. In the language of society, the teacher has arrived.

But the attitude of the public has been changed not only towards the teacher of chemistry; it has likewise been changed toward the science he fosters. In our appreciation of chemistry, the public today has tardily arrived to the point of appreciation of the possibilities of chemistry at which the Germans arrived years ago. It is true that some of the great industrial organizations long since have realized the fundamental importance of the science, but to the great majority, chemistry was largely an unknown field and the chemist was at most a person to be endured. But our country has suddenly awakened, and today the demand for chemists is far in excess of the supply. Indeed, one of the great dangers that is threatening the work of adequately training the students of chemistry in our colleges is the inroad that industrial organizations are making upon the personnel of our instructional force—a condition which, unless forestalled, must seriously affect the efficient training of our future chemists. As a result of this new appreciation, it will be easier to secure the equipment and supplies required for the adequate teaching of the subject.

There is another phase of this general subject that I wish to mention, viz., the possibility of arousing interest in the subject through the study of the application of chemistry to the solution of war problems. I have been greatly interested this fall with my experiences in teaching a class in elementary chemistry, several members of which have had a part in the war. It has seemed that hardly a subject has been discussed that has not been illustrated by war problems. The study of hydrogen brings up at once its use in filling dirigibles. Oxygen leads the way later to its use in making phosgene. Nitrogen opens up the whole subject of nitrogen fixation, one of the most important of war problems, and one in the study of which during the war our Government spent over $100,000,000. The true story of helium rivals the romances of Jules Verne. And so one might continue with the application of chlorine in making toxic gases, of bromine in making lachrymators, of sulphur, thousands of tons of which were

Digitized by Google

utilized in the manufacture of mustard gas. The story of the application of metals is of like interest—of sodium used in one type of incendiary bombs, of aluminum, in another type, of magnesium used in the manufacture of flares for lighting up the battle ground at night and of all the wonderful alloys of iron. How can one better illustrate the use of a catalytic agent than by reference to the use of carbon in the manufacture of phosgene or of kaolin in the manufacture of mustard gas; or how can one impress more forcibly the unsaturated character of carbon monoxide than by the property it possesses of taking up two atoms of chlorine to form phosgene, millions of pounds of which were manufactured as a toxic gas. What better example of endothermic and exothermic reactions than in the formation of carbon monoxide by passing a mixture of oxygen and carbon dioxide over carbon, as is done in the manufacture of phosgene.

A final word—the war is over but our country is faced with problems, the solutions of which are just as imperative for our country's welfare as were the problems of war. In these trying times the teachers of chemistry may well remember the attitude of that great chemist, perhaps the greatest of all times, who over a century ago uttered the memorable words—"I find it my first duty to be a good citizen of my country, and after that, a scientist."

PUBLISHERS' ANNOUNCEMENT

This journal, together with practically all other monthlies, has, during the past five or six months, been seriously embarrassed by labor difficulties, such as strikes and lack of help, also the "flu" has incapacitated many of our best workmen. These troubles have of necessity caused our issues to be two or three weeks late in reaching the hands of our readers. We are asking you to bear patiently with us in these trials. We expect that future numbers will be mailed promptly on or about the 20th of the month preceding the month of issue.

ANNOUNCEMENT.

The Rocky Mountain Teachers Agency of Denver, Colorado, has now five branch agencies, namely: Portland, Ore., 1312 Northwestern Bank Bldg., with Mr. Frank K. Welles, as Manager; Los Angeles, Calif., 636 Chamber of Commerce, with Mr. John C. Epperson as Manager; Chicago, Ill., Lytton Bldg., 14 E. Jackson Blvd., with Mr. H. S. Stice as Manager; Minneapolis, Minn., 327 14th Ave., S. E., with Mr. F. B. Reed, as Manager; and Kansas City, Mo.

The home office and its five branch agencies register teachers without enrollment fee. The Rocky Mountain Teachers Agency was established in 1906 and has long been known for the efficient service it renders to teachers and employers of teachers.

Digitized by Google

SOME PROBLEMS FOR THE CLASSROOM FROM THE ORIENTATION WORK OF THE A. E. F.[1]

By C. A. Epperson,
Teachers College, Kirksville, Mo.

One of the great problems connected with the artillery work of the A. E. F. was to secure men whose mathematical training had been such that they could do simple computations in plane trigonometry by the use of logarithms. One regiment of Coast Artillery lost five officers, two of whom were Captains, by transfer to other branches of the service because they could not pass a simple examination in logarithms. In that same regiment the orientation officer seldom had at any one time more than three or four enlisted men who could compute a traverse or check his work when he had computed it. This deplorable state of affairs necessitated endless work on the part of the officers, training men to do necessary simple computations. Even then the results were unsatisfactory in that the officer never felt that he could trust the results of his new half-baked computer. The mathematical background was not there. This I know to be true of one regiment, and it is my opinion it was true to a large extent of all the Coast Artillery regiments in France.

One thing the war did beneficial to the field of mathematics was to enlist in the problems of the ordnance department a great many mathematicians of first caliber. There have been presented before the American Mathematical Society during the past year any number of papers on ballistics and kindred subjects, and the new discoveries along that line form a very interesting chapter in applied mathematics. But for the schoolroom, and I mean by that undergraduate college work, the field of ballistics has very little to offer. The formulas are largely empirical formulas obtained from the proving grounds, and our schools are not provided with proving grounds and laboratory equipment to carry out experiments. Any new investigations along these lines will probably be done on the proving grounds. Nor do the principles of gunnery as used in the A. E. F. offer much more than does ballistics for schoolroom use. Before a shot was fired, some of the corrections made were for: height of site, curvature of earth, variation in muzzle velocity, density of loading, kind of fuse used, wind, drift, jump, and atmospheric conditions. Of course the problem of height of site or curvature of earth might be presented in the classroom, but the majority

[1]Read before the Mathematics Section, Central Association of Science and Mathematics Teachers at Lake View High School, Chicago, November 29, 1919.

Digitized by Google

of the problems of gunnery would find little place there.

Before taking up the orientation work of the A. E. F. I beg leave to digress a moment. One result of two and one-half million Americans being in France was that they came squarely up against the metric system. When a soldier bought anything in France, he bought it by the kilo or liter. When he marched he marched a certain number of kilometers. When he asked the distance to any place he was told in kilometers. If he measured an angle with the transit or theodolite he measured it in grads. He soon found out that the metric system was simple. He soon learned to think in terms of kilometers. Those soldiers who did computing soon discovered for themselves the immense advantage of the metric system, and became converts to its use. They saw the advantage of dividing a right angle into one hundred equal parts instead of ninety; of dividing a grad into one hundred equal parts instead of sixty; and of dividing a minute in the same way. Some of them learned the relation of centessimal minutes to kilometers on the earth's surface. All of them learned something of the metric system. The result is that we now have in America a few ardent advocates and an immense army of young men who would welcome, or at least not oppose, a change to the metric system.

It has been the writer's observation that our academic courses in mathematics fail in two important things. One of these is that the student does not learn to appreciate the value of logarithms. He does not realize that by the use of logarithms he can carry out long and complicated computations and get accurate results. The necessity of accuracy in their use is not stressed. His use of them becomes slipshod. He looks upon them as a necessary evil he must get acquainted with to pass in his course. He complains that he can do the computations set by the textbook in less time and more easily without them. A great many times he is right. The result is that he gets through his college course with little appreciation of their value. The other fault is that the average student gets through his algebra and analytic geometry without any real conception of the value of the coordinate system. He is inclined to look upon it as something invented by mathematicians to make life miserable for him. He does not see it superimposed on maps. He is not shown the possibility of its use in measuring angles, distances and areas. He thinks of it as a system of lines with the x-axis running horizontally and the y-axis running perpendicularly, and as nothing

Digitized by Google

else. These faults may be due to the teacher, or to the textbooks, or to the student himself. But whatever the cause, they exist. To the teacher who desires to investigate, I offer the following example: set three pegs on your campus in triangular position a hundred or so feet apart. Assign to two of them, A and B, coordinates, as (75, 325) and (196, 32) and require your class in analytic geometry to determine the coordinates of the third point, C, by measuring the distances AB, AC and BC. Require an accurate check of the result. This problem will give some idea of how well your students have mastered logarithms and the fundamental principles of the coordinate system.

With the thought in mind of impressing upon the students the value of the coordinate system by showing its various uses and of teaching them to use logarithms accurately, and also in view of the fact that standard courses in surveying are given in engineering schools for all who desire to become engineers, the course in surveying at the State Teachers College, Kirksville, Mo., was converted largely into an orientation course. The first thing necessary, of course, was to teach the reading of the transit verniers and the various adjustments of the transit. The class then took up the same problems the orientation officer had in France. Since the country around Kirksville is not plentifully supplied with geodetic points, the first thing necessary was to establish known points. This was done by laying out a base line. The coordinates (5,000, 5,000) were assigned to one end of this base line, and the coordinates of the other were obtained by chaining, the base line being considered parallel to the x-axis. This, of course, gave two known points, A and B. The coordinates of a third point, C, were then determined by measuring the angles CAB and CBA. In this manner the coordinates of three other points were determined, giving six known points in all. The determining of these coordinates was the first problem and required over two weeks' time (one hour and forty minutes a day). The instructor's insistence that five one-hundredths of a yard was the maximum error allowable in the result necessitated every student in the class repeating his work two or three times. By that time the students had begun to realize that accuracy was not only possible but was a necessity. Our next problem was to check one of the points, C, by a traverse from A, closing on B. After the traverse was adjusted, the coordinates of C, obtained by the traverse, were found to differ from the coordinates obtained by intersection

Digitized by Google

by nearly one yard. This necessitated running the traverse over, with the result that the coordinates checked to within one-tenth of a yard. The average of the coordinates obtained by intersection and the second traverse were then taken as the true coordinates of C. This gave us the necessary basis for our third problem. A point, P, within the triangle ABC was chosen, and the angles APB, APC and BPC were read, care being taken to secure accuracy. The coordinates of P were then computed and checked by a traverse from A. The two sets thus obtained checked to within two inches. If the reader will solve and check this third problem, he will see that a knowledge of the coordinate system and an ability to use logarithms is imperative.

The fourth and last problem undertaken by the class was the determination of area. An area in the form of a convex hexagon was staked off and the angles and sides measured. It was then computed by dividing into triangles and summing the areas of the triangles. Then the coordinates (0, 0) were assigned to the vertex, A, and the coordinates of the other vertices determined (the x of B being 0). The area was then computed by the formula:

$$\text{Area} = \tfrac{1}{2}\left[\begin{matrix}(a_1b_2+a_2b_3+a_3b_4+a_4b_5+a_5b_6+a_6b_1)\\ -(b_1a_2+b_2a_3+b_3a_4+b_4a_5+b_5a_6+b_6a_1)\end{matrix}\right]$$

The class immediately recognized a labor-saving device.

The result of this experiment was expressed by one of the victims thus: "I wish ———————— (the instructor) had to compute the coordinates of every flag-pole between here and Halifax."

The attendance of students at the University of Chicago during the quarter just closed was the largest in the history of the University. The largest heretofore was that of the Autumn Quarter of 1916 just preceding the entry of the United States into the Great War. In that quarter there were 3,768 in the quadrangles and 1,169 in University College, being a total of 4,937. The registration for the Autumn Quarter just closed shows a total of 4 463 in the quadrangles and 1,219 in University College, a total of 5,682, being a gain of 745 as compared with 1916.

Professor Julius Stieglitz, Chairman of the Department of Chemistry at the University of Chicago, recently appeared before a subcommittee of the United States Senate to give evidence on the importance of establishing American independence in the manufacture of finer chemicals, especially the finer organic chemicals, which in the past have been almost monopolized by Germany. Assistant Professor Gerald L. Wendt, also of the Chemistry Department, recently addressed the Western Roentgen Society on "The Physical Factors Underlying the Use of Radium and Radium Emanation."

Digitized by Google

SCOPE OF GEOGRAPHY IN THE HIGH SCHOOL.[1]

By John Calvin Hanna,
State Supervisor of High Schools, Springfield, Ill.

When children enter the high school they have been studying reading, writing, English grammar, arithmetic, geography and United States history for periods varying from one to six years. And they have, presumably, pretty well covered the ground of the elementary phases of those subjects, in a way and to a degree determined by the stage of maturity which they have reached in their earliest teens. These are looked upon as the fundamentals—these and besides these, if in a favored community where a fully developed elementary school system is in operation, they have in addition learned to read simple music at sight and to express themselves, with some degree of facility, in drawing.

These are the fundamentals; this achievement indicates a certain mastery of the common tools of life—language, number, expression in melodic, as well as in ordinary vocal form, and in graphic representation as well as with the written word. These are the accomplishments necessary for living at all in a civilized community, unless at a very great disadvantage and under a very heavy handicap.

He who cannot "read and write and cipher" is "out of" a vast proportion of the activities that are all about him in daily civilized life; he is dependent upon others at every turn and he is looked upon as being and he is an inferior.

He who cannot sing nor read any music, and he who is helpless with a drawing pencil in his hand, is also under a handicap; he is recognized as being partially dumb, greatly limited in his capacity for higher pleasures and in his power of expression. He must depend upon others to start the tune, to make for him an intelligent diagram.

Yes, but how about geography? Where does that come in? Why should this be included among the units of elementary knowledge? What essential thing does it supply to the one who is to dwell among civilized people?

Man is to live his life—and we try by training him in the use of these common tools to fit him for living that life.

Not only is he to live his life—but he is to live it *on the earth* and, unless he is to stumble and wander blindly and fill his days

[1]Read before the Earth Science Section of the Central Association of Science and Mathematics Teachers, Chicago, November 28, 1919.

Digitized by Google

with awkwardness and blunders, he must know something of that earth—at least of its surface and its relations to the climate, the weather, the commerce and transportation, the use and attainment of the great variety of commodities which fill his life. This in large measure, at least as to its essentials, is given him in his elementary study of geography. He learns directions, boundaries, governments, municipalities, streams and mountains, seas and shores and the multiple forms of the earth's surface; he learns a little of the ways of the weather and the climates and the products of soil and sea and farm and mine and the relation of these to the breakfast table, and to all the luxuries, the comforts, the necessities of life; he learns of the lines of traffic and the causes of their placement.

In short, by his geography, he becomes intelligent enough not merely to read about the deeds of men and to record them, not merely to talk and write about them, not merely to sing and picture them, not merely to keep account accurately of them—but actually to *do them himself*, to be an active participant in the complex activities that spring from and develop into civilization.

Wisely then have the learned chosen these from experience as the things which the adolescent mind has become familiar with when he comes to face youth, and to enter upon its brief and golden period, soon to plunge, however well or ill prepared, into the whirling onward movement of manhood and womanhood.

Similarly, this is the land in which he is to live and he must know something of its history and institutions, at least in an elementary way.

Secondary education in the development of the race as an organized institution preceded by many centuries the formal organization of what we call elementary education.

Man in a barbarous state needed not to read and write and cipher, but he did need to be prepared for tribal membership, for what we call citizenship, by receiving a stiff training in the accumulated wisdom of his tribe before being admitted as a fully equipped citizen to the society of adults. Therefore every known barbarous tribe, when visited and studied by ethnologists, has been found to possess and maintain a fixed and thorough system of secondary education for the training of the adolescent through a longer or shorter course in the period of youth, at the end of which course, conducted in the accumulated wisdom of the tribe, imparted by word of mouth and imparted by the elders

Digitized by Google

of his tribe, with practice and tests, he shall be ceremoniously received as a man into tribal membership. High schools came first!

It was only when the accumulation of tribal wisdom grew to exceed the capacity of memory and the possibility of oral instruction, that man invented written language and number systems, and thereafter the young were "caught younger" and taught the mastery of these common tools. Then and there organized elementary education began—long after secondary education was firmly established. Such present day communities as are ignorant of this great truth, and fail to recognize it in their systems of education, are committing a great wrong and a stupid blunder.

Thus it is seen that there *is* a natural and an ineradicable distinction between the elementary and the secondary school—a line that cannot be ignored.

Vast numbers of our population stop their formal organized education at that line, alas, many of them sooner! And it is well that, whether they *must* stop for economic or other reasons, or whether they go on to inherit the birthright of every child in a free and self-governing land, it is well, I say, that this first period closes with some general knowledge and mastery of these common tools.

The adolescent at the end of grade eight, though not *well* equipped for life and its problems, has in his hand the tools whereby he may with health, energy, intelligence, and good fortune meet and solve for himself or with the aid and supervision of others many of the practical problems that await him. Furthermore, he may sometimes, and to a certain extent, acquire by himself and without formal schooling a part of that knowledge and training for a higher and richer life that secondary education would give him. And if he *can* do this or *any* of this, it is because he is fresh from a training in the use of these common tools, because the elementary knowledges and skills are his.

Then after this elementary training we wish him and her and all of them to go on, to "stick" for four years more, to acquire a secondary education.

We train him further then in the secondary school in written and oral expression; we familiarize him with some of the choicest of the world's literature; we add to and develop his mathematical powers; we give him some knowledge of the world's history and institutions, especially as these are related to those

Digitized by Google

of his own nation, chronologically and biologically; we introduce him to the great world of natural science, giving him first a bird's-eye view of the whole field and a strong impression of the universality and fixity of law in nature, and then later giving him opportunity for closer study in special fields; we give him some knowledge of another language or two, especially that he may more clearly understand and utilize his own; we open the paths of artistic expression and design; we fling wide, in these days, the doors to a pre-vocational training; we point him to responsibility and privilege in connection with civic interests.

The doors of knowledge are opened in a hundred directions with fascinating glimpses of what is beyond, and thus we fit him for life, for citizenship, and furnish him really with his birthright.

And then we turn him loose, to win or lose his way, to remove mountains or dig ditches, to sing songs or do deeds worthy of song, to fight battles or to tell of them and draw lessons from them.

The world is his! And he looks around for his tools. Where is now that ease in the command of language—in reading and writing? Where is now that facility with the marvels of number, that skill in the fundamentals of arithmetic so promptly demanded by his employer? Where is now that study of his country's history and institutions so much needed as he faces citizenship?

Where is now that familiarity with mother earth and her broad contours and salient features, that knowledge so much needed in his life among men on earth of the lines and currents of ocean, of the slopes and plains of land, of the lines and currents of life and the heights and levels of life as determined by the surface of the earth?

Rusty is he in them all—and he can't pass an examination for a second grade certificate! Full of wise saws and modern instances, saturated with theories and formulas for explaining scientific phenomena, his head dizzy with dynasties and popular movements, his atmosphere murky with the problem of Dido's sacrifice or Hamlet's insanity, convinced by his own argumentation concerning the destiny of man—he faces the need for readin' and writin' and 'rithmetic, for grammar and spelling and "joggerfy," United States history and drawing—and the good old studies of the seventh and eighth grades.

And in the opinion of the writer *he ought to have them;* he ought to have just had a fresh view of them, a later view, a more mature

Digitized by Google

view, a study with less of memory and more of thinking through.

All these things in some form belong in the last year or last two years of a high school course and ought to be placed there.

Some of them *are* there. American history is in the last year of every well regulated four year high school, preceded, if the curriculum is properly organized, by two years of European history so studied as to prepare for and explain this re-view (not review but re-view) of America's history, and accompanied by further and matured study of our civil institutions and the individual's relations thereto.

Grammar and reading and composition are there in a well constructed and well balanced course in high school English.

Really in the best and most intelligently conducted high-schools they *are* all there or, without really disturbing any unit already there, they may be placed there and included in the curriculum—all but arithmetic and geography.

And in the humble opinion of the writer these also should be placed there—arithmetic as a half unit and geography as a full unit. The universities are now allowing entrance credit for half a unit of arithmetic properly taught in the third or the fourth year of the high school—and that is the place for it. This is not the occasion for discussing its content or its method, but these should both be determined with reference to the psychology of the seventeen-year-old and the problems so clearly awaiting his use of this later study of the subject.

As for geography, that is surely where it belongs, that is in the twelfth grade, instead of being tucked away as a half unit in the ninth grade. Let the elementary school restore geography—world geography—to its place in the eighth grade. And then in the twelfth grade let it be taught, taught as a science with practical applications. As a science, with library studies of books and current periodicals, and with true laboratory thoroughness in making independent observations, drawing and recording definite conclusions.

"As a science with practical applications"—and what science has so many practical applications and so amazingly varied? Its connection with the whole field of agriculture from drainage to weather, from seed bed to marketing—surely this is self-evident.

With every form and phase of commerce and transportation it is closely linked. The masters of these matters know geography and utilize it.

Digitized by Google

With history and every utilization of its stores of knowledge —history and ethnology, wars and migrations, political institutions and international prejudices—geography really makes and explains them all:

All civic and social institutions and activities have their roots in and their fruits determined by geography. An Italian, an Egyptian and an English revolution are all vastly different, and geography helps to account for and anticipate those differences.

The political genius, the legislature manipulator and the world statesman—all must know their geography.

The enthusiastic member of the Woman's Club must cram up a little on geography; the athlete who goes for a contest from the Mississippi valley to the Pacific coast must take into account geographical and climatic differences; the aviator literally "goes over the map;" the president of the church missionary society must know something of Laos, or Chosen, or the Congo, or Mesopotamia, or wherever her heart is; the soldier in these larger days must know larger geography than the road to Bull Run or Pittsburgh Landing; he who picks up his daily newspaper must pass an examination on a wide stretch of geographical knowledge or else must "skip it," as other stupids do when he comes to something unfamiliar because of his ignorance of geography.

In short, everybody ought to have and needs to have and must soon have a high school education; and if it is a good one it will include near its close a year of high school geography, of wide scope and studied in its relations to the activities of life.

According to the forthcoming annual report of President Judson, a building which the University of Chicago stands especially in need of is a Research Laboratory for the Department of Chemistry. The present Kent Chemical Laboratory is overcrowded with students. During and since the war the need of developing research in chemistry has become increasingly important. A new building fully equipped for research work and advanced graduate work would leave Kent Chemical Laboratory for the ordinary purposes of the Department. Such a building is estimated to cost about $350,000 and would be erected directly west of Kent Chemical Laboratory.

The former head of the University of Chicago High School, Principal Franklin Winslow Johnson, who resigned to enter war service, has been made headmaster of the Horace Mann School for Boys in New York City. The school is conducted by the trustees of Teachers College, Columbia University. Principal Johnson, who was at the head of the University of Chicago High School for ten years, is the author of a successful book on *The Problems of Boyhood*, published by the University of Chicago Press.

Digitized by Google

THE USE OF THE ELECTRON IN ELEMENTARY PHYSICS.[1]

By Daniel L. Rich,
University of Michigan, Ann Arbor.

About one hundred years ago there grew in favor the idea that all ponderable matter is made up of bodies called molecules, and that the molecules in turn are combinations of smaller bodies called atoms. These ideas are embodied in what is known as the molecular theory and the atomic theory, theories to be sure, but theories so firmly embedded in scientific thought, so thoroughly entrenched by experimental evidence, that most students of all phases of natural phenomena now look upon atoms and molecules not as hypothetical expedients, but as actual entities having a real physical, objective existence. In fact, a very large percentage of the accepted so-called explanations of scientific phenomena is based upon the assumption of the existence of atoms and molecules, and all elementary textbooks in all branches of science make free use of atoms and molecules with no hesitation whatsoever due to the fear that such things are too difficult for the beginner.

About twenty years ago the electron sprang into the limelight. It has occupied the center of the scientific stage ever since, probably being actively present in about one hundred per cent of the varied phenomena of nature. I take it for granted that we all believe in the existence of the electron just as firmly as we believe in the existence of the atom and of the molecule, and that all present have at least a speaking acquaintance with the electron theory. Yet in spite of this knowledge about the electron and this belief in the electron, I fear a good many have formed the idea that the electron, unlike the molecule and the atom, is a refined minutia to be found mainly in advanced work in electricity, a highly theoretical entity to be studied in the graduate courses of a university, and to be used only by the research worker.

It is perfectly true that the electron is one of the research worker's best friends. Likewise it is true that some very highly theoretical work can be based on the electron; yet I am coming to believe that there is a very large field of usefulness for the electron in the elementary study of physics and chemistry. The advanced theory of electricity is highly mathematical, but the high school boy and girl can learn a lot about electricity without

[1]Read before the Physics Section meeting of the Central Association of Science and Mathematics Teachers at Lake View High School, Chicago, November 29, 1919.

Digitized by Google

even a knowledge of calculus. It would be foolishness to omit elementary electricity on the ground that an extensive study of electrical theory is beyond the present ability of the high school pupil. Reasoning along the same line, we should not fail to make use of the electron in elementary work simply because some features of the electron theory have to be postponed for more mature minds. Admitting that the electron IS a useful addition to scientific thought, the pupil and the electron should be introduced to each other in high school physics.

The objection that this addition to the subject matter of elementary physics will increase the length of an already badly overcrowded course is an objection worth considering. However, if the introduction, at the very beginning of electricity and magnetism, of the idea of the atomic structure of electricity and the electronic substratum of matter can be made to work a simplification in the treatment, with a resultant increased clearness of presentation and omission of roundabout unsatisfactory explanations that do not explain, and the grouping around a common cause of many apparently diverse phenomena, then the introduction of the electron is justified, and the result can be: fewer pages in the textbook, and clearer pictures in the pupil's mind.

The purpose of my talk is to attempt to convince you, if you do not already agree with me, that the study of electricity should begin with the electron, and that with such beginning a logical development would lessen the difficulties, shorten both the text and the time necessary to start a boy or girl in electricity, and result early in a keener insight into electrical phenomena.

Begin with the idea of the atomic or granular structure of electricity, with the idea that electricity is divisible into particles called electrons. Develop first of all the modernly accepted notion of the neutral atom, an atom not indivisible but made up of separable parts, these parts being a positive nucleus and one or more negative electrons. If some of these negative electrons get lost, the remaining part of such atom is preponderatingly positive, due to the positive nucleus. The other bodies to which the lost electrons have attached themselves exhibit negative electrification, due to the surplus of negative electrons.

In gravitation, experimental evidence causes us to assume the attraction of gravitation, without knowing the cause. With electrons, experimental evidence shows us we need to assume both attraction and repulsion, attraction between negative elec-

Digitized by Google

tron and positive nucleus, and repulsion between negative electron and negative electron, repulsion between positive nucleus and positive nucleus. Action-at-a-distance theory forms the best avenue of introduction. It is already familiar that the earth pulls on objects; the child does not trouble himself to explain why; it is only the vanguard of research physicists who are exerting themselves over the mechanism and the cause of gravitation; beginners are content with the physical facts, with the knowledge that there is such force, and that this force has been given a name—the force due to gravitation. Likewise, the beginner need not be troubled with the cause or causes of electrostatic fields and electromagnetic fields; simply present the facts that an electron at rest does have around it an electrostatic field, and that an electron in motion does have also an electromagnetic field. Further, just as the beginner is not expected to wrestle with the idea of potential of a gravitational field, likewise the beginner need not be pestered with the abstract notion of potential of an electrostatic field. Masses of gravitational matter, molecules and atoms, attract one another; electrons repel one another. Granted these facts, much can be explained.

The best place to begin perhaps is in electrostatics. When a glass rod is rubbed with silk, tell the student that some negative electrons are transferred from the glass to the silk. This presentation makes plain the following several fundamental ideas: first, electricity is not created nor destroyed; second, some bodies can be given more than their proper share of electrons—when possessing more than their proper share of electrons, these bodies are called negatively charged bodies; third, some bodies may be robbed of part of their electrons—bodies having less than their normal share of electrons are called positively charged bodies; fourth, most bodies left to themselves acquire and keep their proper share of electrons, and are called neutral bodies; fifth, the number of electrons lost by one object must appear on one or more other objects, or as we say positive and negative charges are always numerically equal; sixth, since negative electrons mutually repel, and since positive nuclei also mutually repel, the surplus charges, either positive or negative, in any conductor left to itself must necessarily reside on the outside, to be situated as far apart from one another as possible.

Going back now to the glass rod which has lost some electrons to the silk. The glass rod has a deficiency of electrons. How do we explain charging by contact or by conduction? Suppose this

Digitized by Google

glass rod be placed in contact with some other object, a metal conductor for example. Some electrons will flow from the metal conductor on to the glass rod, leaving this metal conductor also deficient in electrons, also charged positive. Suppose an object has a surplus of electrons, as is the case with a rod of ebonite when rubbed with flannel. If this ebonite rod with its excess of electrons be placed in contact with some other object, some electrons will flow off on to the other object, giving it also a surplus of electrons, and charging it as we say negative. The same explanation applies exactly to earthing or grounding a body, with the additional idea that the earth is so large and contains so many electrons, that the small numbers we can control when added to the earth or taken from the earth produce a change in the condition of the earth that is entirely negligible, unmeasurable. When a negatively charged body is placed in contact with the earth, electrons flow to the earth. When a positively charged body is placed in contact with the earth, electrons flow from the earth to the body.

The phenomena of electrostatic induction is readily intelligible in terms of the negative electron. Suppose a body negatively charged, that is, one having more than its proper share of electrons, be brought near a neutral body, the negative electrons in the neutral body will be driven to the other side, and that side will become negative. The nearer side now having too few electrons will be positive due to the preponderating influence of the positive nuclei. If the original charged body be positive, i. e., if it has lost some electrons, the electrons in the neutral body will move toward the nearer side. If a body under the influence of a negative charge be earthed, the body will suffer a loss of electrons; if the ground be removed first, and the inducing charge afterwards, the body will then possess too few electrons, and therefore be positive; while if the inducing charge be removed first, and the ground afterwards, enough electrons will flow back into the body to leave it neutral. The explanation of how an electroscope may be charged positively or negatively by contact and positively or negatively by induction offers no added difficulties. The various changes that may be rung on Faraday's ice pail experiment become wonderfully simple in terms of the behavior of the electron. Whether the charged body in the pail be removed first or last or not at all, whether it touch the pail or not, whether the pail be grounded or not—all the student needs to consider is how the negative electrons move.

Digitized by Google

Now, take up current electricity. Here the historical development of the subject has resulted in an unfortunate state of affairs. By usage the electric current is said to flow from positive to negative, whereas we now all agree that what we call a current of electricity is a real current of free electrons flowing from negative to positive. The customary usage, calling this hypothetical historical current an *electric* current, and the real current an *electron* current, is probably the best way out of the difficulty now; but I see no reason why in another generation or less the term electric current might not have become entirely obsolete and all future literature speak only of the electron current, and give this current its proper sense, for example from zinc to carbon in the external circuit of a Leclanche cell.

Now, what makes these free negative electrons move along a conductor? We often speak of the analogy between water pressure and electric pressure, and usually apologize for the crudeness of the analogy. But is there any necessity for the apology? If gravitational mass and electromagnetic mass should turn out to be one and the same thing, would not a slight change in our systems of units result in there being perhaps not an identity but at any rate a very close relationship between mechanical pressure and electric pressure? And may not the term electric pressure without modification or apology come to be the better expression to use? The ordinary high school pupil has no idea whatsoever concerning gravitational potential, but he does have a clear notion of what altitude means, and of differences in level. Similarly, the ordinary high school pupil at best has only a very hazy notion of electric potential. Would it not be well in high school physics to omit electric potential altogether, and teach him simply in terms of electric pressure and differences in pressure? The student may not know why water runs down hill, but he knows which way it goes, and how to make it go. So, electrically, may not the beginner grasp the idea of which way free electrons flow, and how to make them move, without being troubled with the abstract idea of potential, and without even thinking of work per unit quantity, or of $M^{\frac{1}{2}}L^{\frac{1}{2}}T^{-1}c^{-\frac{1}{2}}$?

At any rate, the idea that a current of electricity is an actual current of free electrons is an idea easy to grasp. It makes easy a clear mental picture of the difference between conductors and nonconductors and of the various grades of conductivity. It suggests more intimate relationship between resistance and friction, and makes plausible the fact that the Joulean heat losses

Digitized by Google

are proportional to the square of the current, i. e., proportional to the square of the velocity of the moving electrons.

The assumption of the electromagnetic field around a moving electron immediately connects magnetic and electromagnetic phenomena; and this assumption coupled with the modern view of the structure of an atom, pictures clearly how a piece of iron is magnetized by bringing the orbits of the electrons into parallel planes.

My talk would be too long if I attempted to discuss the possibilities of the electron in elementary chemistry. Suffice it to say that there is now recognized an intimate connection between valence, chemical affinity, and the number of electrons in the outer regions of the atom. Ions and ionization, dissociation, all electrochemical reactions of various kinds—a vast field and a whole host of phenomena pay homage to the little electron.

The electron is not an ultimate explanation, but it is a satisfying reason why. Its use does result in the unification of the underlying phenomena of nature, of magnetism and electricity, of light and heat, of the radiation and the absorption of energy, of the constitution of matter, of the affinities and the decay and the transmutation of the elements.

It is the biggest little thing that has entered science in historic time, and it should not be relegated to the graduate courses of a university where only one in ten thousand has a chance to hear about it. Put it into the elementary textbook, and strike out the antiquated theories to which it is infinitely superior. Don't tell a class of beginners that electricity is a hypothetical substance which exhibits attraction and repulsion at a distance and shows no orientation; nor that an electric charge is the manifestation of a discontinuity of an ether strain tube. Such metaphysical abstractions to a class that finds even arithmetical subtraction difficult is the height of pedagogical folly.

Better, tell the beginner that electricity is made up of electrons, whose nature is as yet unknown, but in terms of whose behavior a very large percentage of natural phenomena may be explained and understood. The electron won't explain everything, but the difficulties it presents are not so numerous as those presented by older theories; and when it can be used it results in an explanation readily plausible and intelligible to even a beginner.

Digitized by Google

PRELIMINARY INTELLIGENCE TESTING IN THE DEPARTMENT OF PHYSICS, UNIVERSITY OF CHICAGO.[1]

By Harvey B. Lemon,

If one is to regard a general course in physics as coming under the head of intelligence testing, the title of this paper will fairly well fit the subject matter. If, however, by intelligence testing we mean preliminary examination of a student with reference to his degree of fitness for his subject, our title, which was somewhat hastily chosen owing to the necessity of getting the program into print, applies to only a relatively small part of our remarks.

Preliminary intelligence testing in physics at the University of Chicago is merely one feature of the general reorganization which our college courses have been undergoing during the last five years under the immediate supervision of the writer. This reorganization has been necessary because of changing conditions in these strenuous years of flux. Two of the most important of these changing conditions have been the notable development of the applications of physics in industries during the last decade, recognition of which has been tremendously emphasized by the war; and, second, although not independent of the first, a very notable increase in the number of students. Ten years ago this department was running an average of twelve junior college sections, registering an enrollment of 250 students per year. During the present year we have estimated in eight junior college courses, 36 sections and a total of 820 students. Of these 36 sections, 28 are college courses. It is noteworthy that the decrease of registration in the University caused by the war the last two years has not been duplicated in physics and chemistry.

The distinction firmly insisted upon by the University of Chicago between college instruction and preparatory instruction in physics is identical with the distinction between the analytical method of treatment and the descriptive. We hold that no college course which is not analytical is a college course in the sense in which we use the term. We insist that in the vast majority of cases an analytical course cannot be carried successfully by a student who has not had descriptive courses in the subject matter beforehand. For this reason, claims for advanced standing brought from other institutions to us are frequently refused or at least granted only in part when it appears that these college courses have admitted students who have not had high school

[1]Read before the Physics Section, Central Association of Science and Mathematics Teachers at Lake View High School, Chicago, November 28, 1919.

Digitized by Google

physics. We recognize perfectly well that the claim made by some college teachers that they cannot distinguish in their classes people who have had high school physics from those who have not, may be frequently justifiable. Nevertheless any college course which does not presuppose the descriptive work cannot be a strictly analytical course and cannot therefore be equivalent to the college courses of this University.

Our reorganized plan of college instruction appears to best advantage in those courses catalogued as Physics 3, 4, and 5, which constitute the year's sequence given in the fall, winter, and spring quarters, respectively. These courses meet nine hours a week and are expected to consume a total of fifteen hours a week of the average student's time, if time spent on preparation is included. Of the nine hours under definite instruction, one hour is devoted to a demonstration lecture attended by all sections together. Eight hours are devoted to classroom and laboratory exercises with practically an equal division of time between actual experimental work and informal classroom discussion.

The advantage of having a laboratory in which a class can draw up their chairs in front of the blackboard informally for common discussion of questions at any time has been pointed out with considerable emphasis before this association in times past. We consider it one of the vital features of successful teaching. With regard to the demonstration lecture, it has been adopted to a limited extent with a threefold purpose in mind.

First, if the senior men of the department are associated with elementary instruction at all, it is only in the demonstration work that this association can be made. Our elementary classes have an opportunity to become acquainted with Professor Michelson when he lectures on such subjects as the rigidity of the earth, interference of light, measurements of the velocity of light, or on problems in spectroscopy. They become acquainted with Professor Millikan in his lectures on the kinetic and the electron theory. In the course of a year they thus become acquainted with all members of the staff in connection with those phases of modern physics wherein these men have research reputations.

In the second place, there are a great many important applications of physics in modern civilization with respect to which the textbooks are never up-to-date. We have demonstration lectures on the fundamental mechanical principles of flight, on fluid motion, on the gyroscope, on the boomerang, on low temperature phenomena, on change of state, on Brownian motions, on

Digitized by Google

the periodic relations between the elements as brought out in the study of X-rays, on the measurements of "e," on the structure of atoms, on electrical oscillations, on harmonic analysis of sound, on water waves, on applications of spectra to the problems of the stellar universe, as well as to the structure of the atom, on X-ray spectroscopy, on interference and diffraction.

The lectures on these subjects are real demonstration lectures in which upwards of three hundred different experiments are performed before the class. Very careful study has been made to enable the presentation of this material divorced from mathematical complexity. Even such phenomena as the gyroscope and the boomerang have been successfully attacked with no more mathematical machinery than that involved in a vector addition diagram. While some of the apparatus involved is elaborate and costly, by far the major portion of it is simple and obvious.

In the third place, while students are expected to understand and are examined on the material presented in demonstration lectures, these lectures are nevertheless conducted with a view toward general relaxation and relief from the strenuous grind of laboratory routine measurements and computations, and if students' comments are to be taken as any indication, the demonstration hour each week is the most enjoyable of the course.

For the benefit of teachers and advanced students, this demonstration material has been collected into a special single course offered as Physics 7 in the University College during the year and given usually under the same notation as a teachers' course in the summer quarter. When so organized, much more emphasis is laid upon the analytical aspect of the work and the course thus carries senior college or graduate credit.

In the laboratory continual effort is also being made toward modernization of the classical material. The efficiency of the 4-cylinder, 4-cycle gas engine is regarded as a more desirable experiment than one on the efficiency of the water motor. The graphical analysis of the tensions and compressions in a simple bridge of which the model is before the class is thought to be of more value than routine problems assigned on the basis of geometrical figures representing tensions.

We regard it as highly important that the same man be in charge of both laboratory and recitation work, but in view of the large number of sections involved in these courses in each one of which the instructor has full responsibility over classroom and laboratory work, careful coordination must be made. It is im-

Digitized by Google

portant on the other hand that independence in the presentation and entire freedom in teaching be in no way sacrificed. Consequently the general physics course can be accurately described as being given by a committee composed of all of the instructors. The instructors and their assistants meet at frequent intervals to discuss the technique of experiments, problems, text and examination questions, and individual student cases. The final examination is worked out for the entire course by this committee of the whole. The classes are informed of the method used, which promptly establishes a cordial relation between the instructor and his individual group. Student and teacher are cooperating with the ultimate aim of passing the course, the standard of which is fixed on an entirely impersonal basis; even the marking system is not arbitrary but grades are referred to the average of the classes, a procedure perfectly legitimate when numbers of students mounting into the hundreds are involved.

Finally, great care is used in admission and early examination of students in these courses with a view toward discovering their individual lack, either of preparation or of ability and it is here that we come to the subject announced in our title—the question of preliminary intelligence testing.

At the first meeting of all University classes in physics the following data are secured upon a form card from every registrant in each class: Name; age; classification in University, that is to say, A. B., S. B., Ph. B., J. D., M. D., etc.; year in University; high school physics taken, when, where, and with what textbook; previous mathematics courses in high school, in college; previous science courses in high school, in college; other courses taken simultaneously with the present course in physics; why is the student now registered for this particular course in physics. These cards, upon which is entered in due course of time the student's academic history in physics, go into a permanent departmental file and are available for future reference.

At this first session an efficiency test is also given. Questions are dictated and answers are to be written down at once, although sufficient time is allowed on each question to enable the student to put it down on a pad of paper if he so desires. Students are assured, however, that the questions are of such nature that it should not be necessary for them to have to "stop and think" for any extended period. These questions cover high school physics and some arithmetic and algebra. For example:[1]

[1] Some of these questions are taken from that excellent little book, "An Introduction To Laboratory Physics."—*Tuttle.*

Digitized by Google

How much current does a 50-watt lamp consume on a 100-volt circuit?
What is Boyle's law?
How many degrees below zero is absolute zero, and why this number?
What is the difference between yellow and green light?
$(m+x)\ (m-x)\ =?$
Reciprocal of $2/7\ =?$
Solve: $3 : 12 :: 16 : x$
Reduce: $\begin{cases} .395 \\ .005 \end{cases}$ to percentage
Simplify: $a^5 \times a^3$, $a^{3\times 5}$, a^{4+2}
If pv is the constant, how is p affected by doubling v?
Equation $y = ax - b$; solve for x. What is y equal to when $x = 0$?

The results of these questions are entered on the students' record cards and carefully studied before the second class meeting. Students who show averages below 50 per cent have their records carefully scrutinized and are then interviewed. Many of these are clearly out of place and change their registration at once without any further pressure being brought to bear. Others make protest and are always allowed to act in accordance with their own wishes, particularly when they feel that the result of the test is not an accurate indication of their potential capacity for the work.

Some statistics of this year's classes may be not without interest: of 171 registrants, 40 were below 50 per cent and were interviewed; 22 cordially agreed that they were not prepared for college physics and dropped out at once with a loss of but one hour's time in entering another class. Many of these requested advice as to what they should take and acted directly in accordance with it, some going back into preparatory physics, others taking elementary courses in mathematics, some going into chemistry. The remaining 18 students were all warned as to the importance of carefully scrutinizing their reactions in the first few weeks and advised to make special effort. Of these 18, 9 stayed by the work and are now ultimately making good; 9 others dropped within four weeks because of obvious failure to continue with a passing grade. In the last four weeks several other students have dropped, but these cases have almost without exception been due to conditions arising late in the quarter, mostly because of illness, a condition which has interfered with the rest of their University work as well as with their physics.

We find without exception that some of the greatest deficiencies of our students are connected with ideas of mass and weight, and with the definitions of velocity work and power, all of which they should have learned in high school. After three weeks in their college course this fall in which there had been ample review of these notions, the following questions were given:

What is the difference between mass and weight?

Digitized by Google

Define velocity, acceleration, work, power. Answers were graded:
A. Unquestionably correct.
B. Nothing incorrect, but incomplete.
C. Partly right and partly wrong.
D. Entirely wrong.

Out of 425 answers 180 were A or 42 per cent; 112 were B or 26 per cent; 83 were C or 20 per cent; 50 were D or 12 per cent. With respect to the definition of velocity, however, there were only 18 out of 85, or 21 per cent who included the idea of direction in their definition, and these came almost entirely in one section taught by a British trained man who had laid especial stress on the matter. Apparently our students came from high school courses, this year at any rate, entirely innocent of any vector notions or of any distinction between velocity and speed.

It is far too early to attempt any analysis of the situation with respect to our incoming students with reference to the schools from which they come, but we feel that we will soon be in possession of valuable data in this direction. This year we have, out of a total of 171 registrants, 90 from out-of-town high schools and 81 from the high schools of Chicago or its suburbs. Of the out-of-town students, 22 per cent have been doing unsatisfactory work, C— or below, not necessarily failing in all cases, however, and of the city students, 28 per cent fall in the same category. It is too soon, however, to generalize from these results. It is obvious that our records can be analyzed with respect to any individual school as soon as we have a little more time to gather statistical material. We urgently desire to get the cooperation of the high school people, particularly around Chicago, in studying this data, which will, of course, be freely taken up with the instructional staff of any particular school in so far as it relates to that school. It has invariably happened during the writer's experience of the last four years as departmental examiner that cooperation between the University and a high school based upon a mutual discussion of the teaching problems involved in both institutions has resulted in recommendations through the Examiner's Office, the adoption of which has rendered material improvement in the working conditions in the high school and in the equipment of the students which were there being prepared.

In closing, it is needless to emphasize that we do not expect by merely gathering data to solve the great problems of teaching. Anything which pretends to do so can be safely set down as a nostrum and consigned to oblivion. The problems of teaching will differ from generation to generation as human nature shows individual variation.

Digitized by Google

CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS ANNUAL BUSINESS MEETING, NOVEMBER 29, 1919.

The annual business meeting of the Central Association of Science and Mathematics Teachers was held at the Lake View High School, Chicago, Saturday morning, November 29, 1919. President Isenbarger presided.

The minutes of the business meeting of November 30, 1919 were read and approved.

The following report was read by Mr. H. R. Smith for the Committee on Resolutions. The report was accepted:

1. Resolved: That the Central Association of Science and Mathematics Teachers expresses its thanks and appreciation to the Chicago Board of Education for granting the use of the Lake View High School for the 1919 meeting; and to Assistant Superintendent James E. Armstrong for cordial assistance upon the general program.

2. Resolved: That the principal, teachers, and musical organizations of the Lake View High School be voted the sincere and hearty thanks of the Central Association for their generous and hospitable entertainment during our present meeting.

3. Resolved: That formal and special recognition be given to the efficient service rendered by our retiring treasurer, John B. McClellan, during the past four years. His faithful and untiring efforts have contributed much to the position maintained by the Central Association during the period of the war.

4. Resolved: That the Central Association formally express its appreciation of the work of Mrs. Anna Y. Reed in vocational guidance and for her interest in coming from Washington, D. C., to present her theme upon our program.

5. Resolved: That our hearty thanks and appreciation be voted to President Lynn Harold Hough and to Professor Robert A. Millikan for their addresses upon our general program.

6. Resolved: That to the end that schools may be kept open and competent teachers provided, we declare it to be the patriotic duty of taxpayers and lawmakers to provide sufficient revenues to insure a living wage and a saving wage to the teacher of the elementary school and high school.

7. Resolved: That the members of the Central Association of Science and Mathematics Teachers declare the urgent necessity of a Department of Education with a cabinet officer at its head to the end that illiteracy be overcome and education be made more efficient throughout our land.

8. Resolved: That in the constitutional convention of Illinois or of other States, articles in the State Constitution relating to schools be made brief comprehensive statements of principles, rather than detailed regulations of particular conditions.

Willis E. Tower, Chairman.

The following report of the Committee on Nominations was read by the chairman, Mr. Harry D. Abells: President, J. Albert Foberg, Crane Technical High School, Chicago, Illinois; Vice President, Frederick R. Gorton, State Normal College, Ypsilanti, Michigan; Treasurer, Lewis L. Hall, Morgan Park High School, Chicago, Illinois; Corresponding Secretary, Ally L. Marlatt, University of Wisconsin, Madison, Wisconsin; Assistant Treasurer, E. S. Tillman, High School, Hammond, Indiana.

The present secretary was elected last year for a two-year term.

By vote of the Association, the Secretary was instructed to cast the white ballot for these nominees and to declare them elected.

Digitized by Google

The following report of the Committee on Necrology was read by Mr. C. H. Smith:

During the past year reports have been received of the death of two of our members.

Miss Celestine Rice was a member of the Biology Section of the Association from 1908 until the time of her death. She was a teacher of science in the high school at Decatur, Illinois, for eight years and later teacher of science and dramatics in the high school at Lincoln, Nebraska. Her record as a teacher in both positions was an enviable one. To quote from a letter from her superintendent at Lincoln: "Miss Rice was a very unusual woman and a very exceptional teacher, the best high school teacher of biology I have ever known. She was not only exceptionally good in the class room but a powerful factor for right things in the general life of the school. She was a pioneer in the dramatics of the Lincoln High School, but won her way rapidly and created a demand, both from student body and faculty, for the best."

James E. Weyant, long a member of the Central Association of Science and Mathematics Teachers, died on May 25, 1919. Mr. Weyant was born in Elbridge, Michigan, on the 25th of July, 1874. His bachelor's degree was obtained at Albion College, and his master's degree at the University of Michigan. For the past ten years Mr. Weyant was in charge of the physics department of the Shortridge High School, Indianapolis.

The report of the Committee on Advertising follows:

The work of the committee began early in April, at which time letters were sent to the fifty advertisers who had used space in the 1918 booklet, asking for renewals of their contracts. At about the same time, twenty-five additional letters were sent soliciting advertisements from other firms. By the middle of June signed contracts of renewals had been received from about two-thirds of the old advertisers. Further correspondence during the summer and early autumn resulted in securing renewals from most of those who had not responded to the first letter. Several of our former advertisers at first declined to renew, but after writing them again, or, in a few cases, after a personal interview, they agreed to take space. Only two of last year's advertisers failed to renew. From time to time, during the summer, letters were sent out to advertising prospects in an effort to add to our list, and in some cases personal calls were made. The net result of these efforts was eight new advertisers making a total for this year of fifty-six.

The value of our booklet as an advertising medium is illustrated by the fact that one of our advertisers increased his space from half a page last year to a full page this year, while another increased from one page to four pages. One of our new advertisers is using three full pages.

The total amount of space contracted for was fifty-three pages the income from which is $548. George Sype, Chairman.

After showing by applause its appreciation of the committee's good work, the report was accepted.

Following is the report of the Membership Committee:

The methods followed by the committee this year have been substantially the same as those used last year.

A brief article, "How It Grips," was printed in connection with an application blank and sent by the Treasurer to each delinquent.

A letter dated September 15 was sent to about 2500 teachers, chiefly in the neighboring states. These letters were printed on the letter head of the Association and enclosed in a one-cent envelope, which also bore the name of the Association.

Digitized by Google

Early in October a letter was addressed to a member of the Association in each of the high schools in and near Chicago asking that person to assume the responsibility of collecting dues from present members and to enroll new members.

A letter addressed to members was printed in SCHOOL SCIENCE AND MATHEMATICS for October urging their cooperation in securing new members.

Footnotes for the different pages of the program were also prepared.

In addition to the work done by the members of the committee, the President of the Association wrote a follow-up letter to representatives of the Association in the different schools, had an appeal made to each Mathematics and Science section of the all-day meeting in Chicago, November 14, and had the interests of the Association presented at the sections of the University of Illinois Conference, November 21.

Following the usual custom, copies of the program were sent to those on the list prepared by the committee. Copies were also sent to the teachers of science who attended the conference at the University of Chicago last spring. Charles S. Winslow, Chairman.

REPORT OF THE COMMITTEE ON RAILROAD AND STEAMSHIP MAPS.

Your committee chairman sent a letter to Director General Hines making general protest against the quality of railroad maps used in folders and advertising in general, asking him if anything could be done to improve the quality of such maps and suggesting the preparation of a rather large scale map which could be put out in pocket atlas form for use by teachers and travelers in general. This letter was referred to the Assistant Director, Garret Fort, from whose reply the following extracts are taken:

"By the usual railroad map I assume you mean the one in the time table folders. Such maps are not presumed to be accurate maps from a geographical standpoint and not intended to convey the information mentioned in the fourth paragraph of your letter. For many reasons it would be obviously impossible to have such a map in the ordinary time table folder. As to a detailed map of the U. S. A. showing all transportation lines, contour lines, drainage, and other information as suggested by you, I cannot see the obligation of the railroads to furnish such a map. If there is a commerical demand for them, I have no doubt that any of the large map publishers would be glad to give consideration to your suggestion."

The pocket atlas suggested is an idea which your Chairman has long had in mind and he has put it up a couple of times to one of the map publishing houses. He will try again. In his own traveling experience he sees the need of it constantly. What we need is a very accurate map which will show the true positions of all railroads and a plentiful detail of towns, and he should like to see it made with contours to bring out the highlands and lowlands; with the map printed in colors to the contours. Such an atlas would be about four inches by ten, opening out to a double page of about eight by ten, and the country would be covered by thirty or forty rectangles of this size.

This would make it possible for the traveler to have the detailed map in his pocket or in his bag, which would give him all of the railroads to a given town and a great deal of information which he wants and is not now able to get short of the library.

The committee desires to submit this report with the request that the committee be dismissed since it seems that there is nothing further for it to do. J. PAUL GOODE,

Chairman.

Digitized by Google

Mr. John H. McClellan read the report of the treasurer. It showed receipts for the year of $2,676.02, expenditures of $2254.49, and a balance on November 28, 1919, of $421.53. The net constitutional membership on November 28, 1919, was 1077, and the paid-up membership on the same date, 977. He spoke of the duty of each member to secure others and enlarged on the benefits covered by the $2.50 fee.

It was voted to accept the report.

Mr. M. J. Newell reported that the Auditing Committee had found the Treasurer's books and statements correct.

Mr. McClellan asked for an official audit at the time he turns his books over to the newly elected Treasurer. It was voted that the Treasurer close his books on January 1, 1920; that an audit be made at that time by a committee to be appointed by the President; and that a report of Treasurer and Auditing Committee be made to the Executive Committee at its January meeting.

Two proposed amendments to the constitution were presented for consideration.

The first was presented by the Earth Science Section in accordance with instructions voted by its members on November 29, 1918. It had been sent to SCHOOL SCIENCE AND MATHEMATICS for publication in accordance with constitutional requirement, but had been missent and so was not printed. The president stated that on the advice of the executive committee he would rule that announcement of intention to present the amendment having been made at the general meeting of November 28, 1919, the constitutional requirement to publish had been met and so action might be taken.

"It is proposed by the Earth Science Section to amend Article 4 of the constitution by substituting the term 'geography' for 'earth science.' As amended, the article will read:

"This Association shall be divided into sections as follows: Biology, Chemistry, General Science, Geography, Home Economics, Mathematics and Astronomy, and Physics. Each section shall be composed of the members of the Association who are especially interested in the subject represented by the section. At the time of making application for membership, a candidate should indicate the section or sections of which he wishes to be a member."

It was moved, seconded, and carried that Article 4 be so amended.

In accordance with constitutional requirement, the following notice of proposal to amend Article 5 was published in the November, 1919, number of SCHOOL SCIENCE AND MATHEMATICS.

"Last year it was voted to suspend publication of the proceedings in the hope that an increase of dues would not be necessary, but in spite of this economy, the Association finds that it must have more income or further decrease the quality and the amount of its service to its membership. It is for the purpose of avoiding such a calamity that a committee appointed from the Executive Committee, after thorough investigation, makes the following recommendation for an amendment to the constitution, to go into effect December 1, 1919.

"Resolved that Article 5 be amended to read as follows:

"The annual dues of active and associate members shall be three dollars ($3.00), payable at the annual meeting for the following year. Members in arrears for one year shall be dropped from the list of membership."

After Mr. McClellan explained why rising costs of everything being bought by the Association made such an increase of dues necessary, it was voted to adopt the amendment.

It was then voted that the new amendment regarding dues go into

Digitized by Google

effect January 1, 1920, and that members in arrears be served notice that $2.50 will be accepted in payment of dues until that time.

The meeting then adjourned. HARRY O. GILLET,
Secretary.

TREASURER'S REPORT, NOVEMBER 28, 1919.

RECEIPTS.

Balance at report, November 29, 1918		$ 451.87
Refund Earth Science Section expense		2.00
Advertisements in 1918 programs		356.00
Advertisements in 1919 program		40.00
Membership dues at $2.50	$1,777.50	
Membership dues, irregular	48.65	
Total Membership dues		1,826.15
Total receipts		$2,676.02

EXPENDITURES.

Subscriptions to SCHOOL SCIENCE AND MATHEMATICS		$1,227.05
Subscriptions to American Journal of Home Economics		78.00
Programs 1918, printing and distributing		431.63
Biology Section, expense	$ 7.50	
Earth Science Section, expense	12.00	
General Science Section, expense	27.32	
Home Economics Section, expense	2.00	
Executive Committee, expense	3.00	
Mathematics Section, expense	10.83	
Physics Section, expense	3.50	
Badges 1918	15.50	
Badges 1919	20.10	
Convention speakers, 1918	40.00	
President's expense	5.60	
Membership Committee, expense	83.00	
Secretary's expense	9.01	
Treasurer's postage	55.00	
Treasurer's clerical expense, 1917-1918	50.00	
Treasurer's clerical expense, 1918-1919	50.00	
Treasurer's bond, 1918-1919	2.50	
Advertising Committee, expense 1918	12.95	
Printing and stationery, 1919	101.50	
Refund to advertiser	6.00	
Refund to member	.50	517.81
Balance, November 28, 1919		421.53
		$2,676.02

MEMBERSHIP REPORT FOR THE YEAR ENDING NOVEMBER 28, 1919.

Paid-up membership, November 29, 1918	977
Honorary membership	9
Total membership	986
Delinquent, but left on list as per constitution	170
Total names remaining on list, November 28, 1919	1,156
New names added during the year	156
Total	1,312

Digitized by Google

Resigned during the year	61	
Deceased or dropped for delinquency	174	235
Net constitutional membership November 28, 1919		1,077
Paid-up membership, November 28, 1919		907

JOHN H. McCLELLAN,
Treasurer.

REPORT ON EXCURSIONS.

EXCURSION TO LINCOLN PARK.

The party from the Biology Section, all out-of-town teachers, went on the excursion. We went first to the Academy of Science. Here we examined the mushroom exhibit, then the many other exhibits of the building. We last entered the celestial sphere at the top of the academy and viewed the starry groups. Several times out-of-town teachers remarked: "I am so glad I came."

On our way from here to the flower conservatory we passed through three of the animal houses and the bird house, and last of all visited the conservatory. Out-of-town teachers think we have a great advantage in having access to such places. Probably we should use them to an even greater extent than we do.

V. O. GRAHAM,
Instructor in Botany, Lake View High School.

A TRIP TO THE PLANT OF THE LINDSAY LIGHT CO.

A party of the members of the Chemistry Section of the Central Association of Science and Mathematics Teachers spent a very interesting afternoon, November 29, inspecting the plant and chemical products of the Lindsay Light Co., at 161 E. Grand Ave., Chicago, Ill., manufacturers of gas mantels.

These mantels consist essentially of a woven mantel on which is deposited 99 parts of Thorium nitrate and 1 part of Cerium nitrate, which burns to the oxides of these metals. As a result of the war, their supply of Thorium nitrate was stopped so that they were face to face with the alternative of developing a process of making Thorium nitrate from the ore, or of going out of business. With true American resourcefulness, they tackled the job, making as small expenditures as possible and increasing the equipment as new details were worked out. Naturally the plant seems crude and unattractive in appearance, but the main thing is that they were very successful, so that only fifty per cent of the Thorium nitrate made by them is necessary for their own mantels, and the remainder, together with many other rare metal products, are disposed of to other manufacturers.

The details of the processes in the plant, together with the chemistry involved, was ably and interestingly told by Mr. Brendt of the Lindsay Light Co. The process, like that of our new dye industry, represents one of many manufacturing processes which because of the war, the American people found it necessary to work out, and thus prove that we can be independent of foreign manufacturer. Many of these processes will become permanent additions to American industry, and thus they form a silver lining to the terrible war cloud.

G. P. DRUECK, JR.,
Dept. of Chemistry, Nicholas Senn High School, Chicago, Ill.

EXCURSION TO THE UNDERWRITERS LABORATORIES.

Although the Physics Section of the Central Association of Science and Mathematics Teachers had an all day meeting with the American Physical Society in the Ryerson Laboratories, University of Chicago, a number of the physics teachers left this meeting to join a party of the General Science Section and others, Saturday afternoon, November 29, at the Underwriters Laboratories, 207 E. Ohio St.

Digitized by Google

The party was first assembled in an elegant reception room, and truly elegant in its decoration and furnishings, in spite of the fact that it was of fireproof construction. Here a brief history of the institution and the character of its work was given by Vice-President Small. As the party numbered over forty, it was divided into three groups, and each group was assigned a guide who explained in detail the work in each department of the institution, as the groups were taken from room to room.

This excursion can be arranged each year with value to the Association, if the matter is taken up early with Mr. Small.

JOHN K. SKINNER,
Physics and Mathematics, Senn High School, Chicago, Ill.

REPORT OF MEETING OF BIOLOGY SECTION.

FRIDAY, NOVEMBER 28.

At the opening of the meeting a suggestion was made by the chairman, Mr. C. L. Holtzman that Miss Emma Francis of the Battle Creek, Mich., Sanitarium be invited to come over from the Home Economics Section on Saturday morning and give her exhibit of rats fed different experimental diets. This was assented to unanimously.

The chairman then announced the Committee on Nomination of Officers: Chairman, Fred T. Ulrich, Plattville, Wis.; C. P. Shideler, Joliet, Ill.; Helen Southgate, Michigan City, Ind.

Dr. A. S. Pearse, of the University of Wisconsin then gave his illustrated lecture on "Tropical Nature." This lecture was of great interest to the members of the section, as it was illustrated by lantern slides made from pictures obtained by Dr. Pearse in an extensive study of both plant and animal life in Hawaii, the Philippine Islands, and tropical South America. Among the many studies of life made in the tropics and illustrated by slides the following were of absorbing interest:

The Fiddler Crabs—their burrowing habits, mating, fighting of males, the peculiar Ghost Crab.

The tropical rain forest of South America, with its coffee plantations on the uplands, the bananas of the lowlands, the strangling tree (Clusia), the Bromelias among plant life and from animal life were shown such as the deadly bushmaster, the great centipedes and millipedes, the tarantulas, giant land snails, the peculiar snap dragon toad, foraging ants, the ants also which live in the acacias and both bite and sting, leaf-cutting ants, which build galleries that sometimes extend 1500 feet underground.

Views from the swamp life of these forest regions were shown, with their mangroves and alligators.

Then in contrast to the foregoing were many slides exhibiting the life of the mountain streams of the high Sierras with their curious catfishes and mud-eating fishes.

Lastly were shown pictures taken by Dr. Pearse of the desert life of the South American tropics with giant cacti from thirty to forty feet in height, snails which aestivate, harvester ants, which store grain under ground, desert hermit crabs and desert terrapin

Next was read a paper by Dr. Wm. Crocker, University of Chicago, on "Gypsum as a Fertilizer." As this paper will be published in SCHOOL SCIENCE AND MATHEMATICS," no comment need be made upon it in this report. No brief comment could do justice to the paper.

Miss Elizabeth Foss of North High School, Minneapolis, read a paper on "Greenhouse Laboratories in the Minneapolis Schools." This brought out many questions which showed the interest in the tendency just now toward the greenhouse as a valuable adjunct to the biology laboratory. This paper will also be published so that further comment is unnecessary.

Digitized by Google

The Friday session of the section closed with a report made by Harold B. Shinn, of the Shurz High School, Chicago, on the progress made by the reorganization committee upon the subject "Our Aims in Biology and the Measurement of Results."

This report showed the result of a questionnaire sent out to teachers by the committee in order to determine the opinion of citizens other than teachers" as to what the aim in biology teaching should be. It was found that only a fraction of those to whom the questionnaire had been addressed responded; but the results had been tabulated by Mr. Shinn so as to show an interesting situation.

The tabulation was put under two heads, viz, (1) The Aim in Biology Teaching, (2) What Shall be Taught? Under the first head the result showed that public opinion gave "ability" the most important place with "appreciation" coming second. Under the head of "What Shall Be Taught?" the results were very much less definite.

Considerable discussion followed the report. Dr. Eliot R. Downing, another member of the committee made further explanations and showed the difficulties encountered by the reorganization committee on account of the small number of responses, there being only about fifteen per cent of the total to whom the questionnaires were sent.

This committee is to be continued another year and it is hoped that greater cooperation of the teachers may be secured.

SATURDAY, NOVEMBER 29.

Miss Emma Francis of the Battle Creek, Mich., Sanitarium came over from the Home Economics Section and gave a very interesting and instructive talk on her exhibit of rats fed on experimental diets.

Following this the committee on nomination of officers for 1920 reported the following who were unanimously elected: Chairman, Grace J. Baird, Bowen High School, Chicago; Vice-Chairman, C. P. Shideler, Joliet Township High School; Secretary, Elizabeth Foss, North High School, Minneapolis, Minn.

The first of the two remaining topics to be taken up was "The Boys' and Girls' Club Movement." Mr. O. H. Benson, of the States Relation Service, United States Department of Agriculture, was on the program for an address upon this topic, but was unable to be present. His place was taken by Mr. T J. Newbill, sales manager for the Burpee Can Sealer Co. Mr. Newbill was until recently assistant to Mr. Benson in the States Relation Service. He presented this important question in a clear, concise manner. The guiding thought of the movement is "Ownership as an incentive to stimulate the boys and girls to work along the right lines," as was shown by the speaker.

A few of the more conspicuous thoughts developed in the address were as follows:

"The present system of education is appealing more to boys and girls than the fairy tales of the nursery."

"Socialization" the great need in the country districts.

"Homelife" the biggest thing in education.

The great importance of a sense of "management" in the education of boys and girls.

We hope to have this address published in full in SCHOOL SCIENCE AND MATHEMATICS.

"Home—School Projects in Cook County, Ill." was the last subject of the program and was handled by Mr. Edwin J. Tobin, County Superintendent of Schools of Cook County. The speaker knew his subject thoroughly and knew how to present it. Furthermore, it came with authority. Superintendent Tobin is an enthusiast with regard to this move-

Digitized by Google

ment, and has the inspiration which is born of enthusiasm The results achieved in the Cook County schools speak for themselves.

Some of the more important points brought out in this address were as follows:

In the past the school system has not been organized to teach children to do things.

Home-school projects can be done in the school only to a limited extent. They must be carried out largely in the home.

The school system should see to it that the home-school projects are carried out in the home.

The power of the school system alone can make this work succeed.

The speaker by no means confined himself to generalization, but went into details in the discussion. He said that in Cook County when a child reaches the fifth grade, he must undertake a home-school project. That from ten to fifteen per cent is added to his academic grade if the project is carried through satisfactorily, and that "achievement credit" is given to stimulate the work. Graduating exercises are held when achievement credits and emblems are awarded.

Much of the matter presented by Superintendent Tobin was a revelation to members of the section.

Adjournment.

MINUTES OF THE CHEMISTRY SECTION.

FRIDAY AFTERNOON, NOVEMBER 28.

About forty-five were present when the meeting was called to order by the chairman, Mr. S. R. Wilson. The committee on reorganization appointed at the 1918 meeting was responsible for the program of this meeting, reporting on the work it had done, its findings, and its plans for the future. The work of the committee in studying "Fundamentals in Subject Matter" was presented by Mr. R. W. Osborne, Francis W. Parker School, Chicago:

I. FUNDAMENTALS IN CHEMISTRY.

Reorganization, if it is to be successful, must be based upon a clear understanding of two things: first, the reasons, failures, shortcomings which make reorganization necessary; and second, the purposes and aims which are to be attained as a result of the work.

Your committee, therefore, as its first task undertook to redefine the purposes and aims of our chemistry teaching, to formulate the objectives (to use a more recent term) which we want our classes to reach as a result of their study of chemistry. Instead of attempting to evaluate these objectives relative to one another it seemed wisest to the committee to arrange them in their psychological order, that is in the order in which the pupil should become conscious of them. The results of this work were embodied in the first section of the questionnaire which, I am sure, has been received by most of those present. Additional copies have been prepared and are available for getting before you more quickly the report of the committee. These objectives, restating them more briefly, are:

1. Supplying motive to the pupil through his conception of the value of the work to himself and the opportunities for achievement which it offers.

2. The understanding of, and the ability to use the scientific method of procedure as a means of solving his problems.

3. Acquisition of knowledge as a basis of skill.

4. Appreciation, which means the comprehension and understanding of the phenomena of life.

Digitized by Google

5. Ethical and moral values through conceptions of the universe as governed by law unchanging and ever operative.

Forty-two replies to this statement of aims showed thirty-seven in entire agreement and five with only slight modifications. With this agreement on aims the committee next attempted to formulate the content of the chemistry course as far as possible, listing concepts rather than materials. This made up the second section of the questionnaire and replies were obtained in such a way as to indicate whether a given concept was considered fundamental, or though taught not stressed, or omitted from the course.

The results of this section of the questionnaire are given on the mimeographed sheets. With only a few exceptions the groups, laws, theories laboratory technique, topics, and types of chemical change show a very high degree of agreement. This indicates that chemistry teachers are in harmony as to these fundamentals.

In the matter of applications in home and industry the method of scoring indicates only that a particular topic was emphasized. No great agreement could here be expected, in fact it could hardly be desired since local conditions, nearness to particular industries, varying interests of different classes and individual pupils are all factors which would make differentiation necessary and desirable. The results of this part of the questionnaire are interesting as showing what applications are most widely used, and perhaps in suggesting others, which might be profitably employed.

SUMMARY OF QUESTIONNAIRE.

Aims of Chemistry:	Unqualified Agreement	Slight Modification
Aims of Elementary Chemistry in the High School	37	5
Concepts:	**Considered Fundamental**	**Not Stressed**	**Omitted**
I. Laws			
Dalton	40	2	0
Avogadro	39	2	1
Charles	39	3	0
Boyle	39	3	0
Gay Lussac	39	2	1
Periodic Law	31	10	1
Berthollet	28	8	6
Mass Action	26	11	5
Raoult	23	13	6
Henry	20	16	6
Faraday	19	12	11
Dulong and Petit	16	9	17
Vant Hoff	10	16	16
II. Theories			
Molecular	42	0	0
Atomic	42	0	0
Ionic	40	1	1
III. Simple Laboratory Technique			
Manipulation	39	3	0
Tests for Ions	37	5	0
Titration	32	9	1
Cleanliness and Order (Added)	1		
IV. Topics			
Elements, Mixtures, and Compounds	41	1	0
Metric System	41	1	0

Digitized by Google

Matter and Energy	41	1	0
Solution	40	1	1
Anhydrids	40	2	0
Valence	39	3	0
Nitrogen and Carbon cycles	38	3	1
Carbon Compounds	34	8	0
Hydrates	32	10	0
Allotropy	30	12	0
Osmosis	26	7	9
Colloids	24	10	8
Isomerism	22	14	6
Crystalloids	21	12	9
Radio-activity	20	16	6
Critical Temp. and Pressure	17	12	13
V. Types of Chemical Change			
Oxidation and Reduction	41	1	0
Hydrolysis	41	0	1
Metathesis	40	2	0
Catalysis	40	2	0
Electrolysis	38	4	0
Equilibrium	37	5	0
Fermentation	36	6	0
Activity Series	33	8	1
Photosynthesis	33	9	0
Added			
Common metals and groups	1		
Exothermic and endothermic changes	1		

VI. Applications in Home and Industry

Sanitation and Health	26	Matches	18
Foods and Nutrition	25	Electroplating	17
Metallurgy	25	Textiles	17
Water Purification	24	Paper	17
Fuels	22	Refrigeration	17
Cement	22	Illuminants	17
Lime	22	Paint	17
Antiseptics	22	Laundering	17
Disinfectants	22	Abrasives	15
Glass	21	Insectitides	15
Sulphuric Acid	21	Fungicides	15
Pottery	20	Inks	11
Bleaching	20	Cosmetics	7
Adulterants	20		
Preservatives	20	Added	
Photography	19	Alloys	1
Drugs	19	Oils, Resins and Gums	1
Poisons	19	Leavening Agents	1
Antidotes	18	Sugar	1
Dyeing	18	Coal Tar	1
Explosives	18	Rubber	1
Fertilizers	18	Leather	1

"Aims in Chemistry Teaching":

1. The Awakening of the Minds of Pupils to the Possibilities of Achievement.

Our American youth are using only a very small fraction of their powers in study. We must stimulate, energize, motivate, and galvanize them into a greater exercise of mental power. We must get them to be-

Digitized by Google

lieve the fact that lack of effort is the main thing that keeps them from success.

2. The Understanding and Use of the Scientific Method of Procedure.

"To find the facts and know the truth." The only method that "brings results."

3. Acquisition of Knowledge which Serves as a Basis of Skills.

"Knowledge is power."

4. The Comprehension and Understanding of the Phenomena of Life

If the first three aims are achieved, then the pupil has arrived at the goal of self-realization. He is ready to believe with you that work is "man's greatest blessing." Drudgery is banished by intelligence. Common-places are wonderful. He is a socialized being, ready for world citizenship.

5. Recognition of Moral Law.

The inculcation of moral law by the concepts of a well-ordered universe. "Whatsoever a man soweth, etc."

II. "Fundamentals in Method, New and Old," Mr. C. J. Pieper, University High School, Chicago. Summary: The early lecture method of teaching chemistry created in the students a real interest in the subject, and gave the teacher the opportunity to thoroughly organize the subject matter, emphasize the essentials, and establish relationships between facts and principles. The course was intensive and in the end the student was able to see it as a continued story with each chapter in its proper order and setting.

The text book method followed quite naturally as the science developed and more extensive courses were required. The lecture method and the text book method are not the natural method of learning, and the slower students, especially, did not thrive on the predigested knowledge administered in predetermined doses.

The laboratory method was then developed and the student was asked to discover every fact for himself and to verify every principle. No account of economy of time was taken, and no effort made to relate the laboratory work to the larger topics or problems. Usually there was no relation between the laboratory and the class work.

The present method used by the progressive teachers is a combination of the good features of the lecture, text book and laboratory methods. Subject matter is of secondary importance. The primary aim is to develop the scientific point of view, the ability to see and solve problems. Each problem is attacked in the manner that promises, in the opinion of the teacher, to give the desired results with the greatest economy of time and effort.

Opinions of teachers as to the best methods of attacking certain problems differ widely, and must differ so long as they remain mere opinions. Teachers must apply the experimental methods of their own science to their teaching, and thus secure facts on which to base judgments as to the best methods of presenting topics.

The future course in chemistry will be a course of solving chemical problems, of establishing chemical concepts. Each problem presented in discussion, assigned reading, lecture or demonstration, will be given by the method that trial proves to be most successful in arousing interest. The problems should be large enough to include many smaller problems and topics, so as to enable the student to see the broader relationships. The evidence needed to solve a problem will be gained in any way possible, demonstration, experimentation, reading, or consulting authorities. All experimentation must be carried out with a clear purpose in the

Digitized by Google

students' minds. Experimentation should not be resorted to when assigned reading or demonstration would yield the evidence in less time and more certainly. There should be frequent short discussions during and after the gaining of evidence. The teacher should collect exhibits, charts, descriptive pamphlets of industries, city, State and Government reports and bulletins, etc., and should classify and index all this matter so that the students can consult it without loss of time. The student will keep a comprehensive notebook, containing laboratory notes, class notes, text notes, and notes on outside readings, trips, etc.

As problems for experimental teaching, Mr. Pieper suggested the following:

1. Notebooks or no notebooks.
2. Notebooks on laboratory experiments only, or complete notebooks on course.
3. Diagrams and drawings of apparatus, or none.
4. Group versus individual laboratory work.
5. Homemade apparatus versus ready made.
6. Notes in laboratory versus notes written at home.
7. Notes graded with pupil, versus grading in absence of pupil.
8. All work in laboratory and class room and no home work, versus present plan with some home work.
9. Demonstration versus individual experimentation.
10. Oral directions versus printed directions.
11. Projected illustrations versus text-book illustrations.

III. Round Table Discussion of Fundamentals. Dr. A. L. Smith, Englewood High, Chicago. The complete notebook on the course suggested by Mr. Pieper should be separate from the regular laboratory notebook. The laboratory notes should be written in the laboratory and not outside, for the work done outside is likely to be copied.

Mr. Pieper. The laboratory notes should be written in the large notebook, and not in a separate notebook. The teacher needs examine only parts here and there. At University High School the complete notebook is being tried out by one class, while another class of the same grade is following the old plan. Results so far indicate that the complete notebook is a great help to the students. The classes number 18 and 23, and have seven periods a week.

Mr. Frank B. Wade, Shortridge High School, Indianapolis, Ind. One lesson to be learned from the old lecture method is that we should abridge our courses and not try to cover too much subject matter. The immaturity of the high school pupil is an additional reason for the failure of the lecture method. Frequent repetition is needed to fix the fundamentals, and we would probably have better success teaching the theoretical parts of chemistry if we took the time to permit our pupils to acquire many facts and then generalize the laws, and imagine theories to account for them. In the laboratory the sections should be small enough to permit the teacher to get around often enough to be sure that every student knows definitely what he is doing. If the work in hand is treated as a project we will be most likely to be guided into a correct blending of the different types of method. If we can get a member of the class to invent our projects, all the better, but if projects are not forthcoming, let us invent our own. After a student has made such a marvelous notebook as Mr. Pieper describes, he could lose the document itself without suffering great loss, for its chief value to the student is in the making of it. Experimental teaching is the only way to arrive at definite knowledge as to best methods to use. The value of repetition at protracted intervals was shown by Prof. Arthur L. Foley, of Indiana University, in a paper

Digitized by Google

read at a recent meeting of the Indiana Teachers Association, in which he reported on the results of hundreds of examinations in physics given to entering freshmen at Indiana University, and in which he stated that those who had had both chemistry and physics in high school were quite uniformly successful in working problems based on Boyle's and Charles' laws, while the others as uniformly failed. The advantage of having an opportunity to review and to use in a new connection at a somewhat later time, and after some considerable mental development has intervened, any portion of knowledge, is apparently very great.

Mr. S. R. Wilson, Culver Military Academy, Culver, Ind. It is very difficult to make pupils realize the real meaning of chemical terms and formulas. Few ever get the notion that H_2O means wet.

Mr. B. J. Rivett, Northwestern High, Detroit, Mich. Used to have notebooks written up at home, but there was too much copying. When more time was allowed for the subject the notes were written up in the laboratory and a great improvement resulted. Notes ought to be corrected in the laboratory also, as this is a great saving of the teacher's time and energy, and makes it easier to call the pupil's attention to errors of fact, conclusion, English, spelling, etc. But where can one get the time for Mr. Pieper's complete notebook?

Mr. Pieper. Abbreviate the course.

Mr. Wm. Tydeman, Ottawa High School, Ottawa, Ill. An interlinear notebook is working out very nicely at Ottawa.

Mr. C. M. Wyrick, Crane Junior College. When teaching high school chemistry had the pupils provide a pad and carbon sheet. All notes were written in laboratory, pupil keeping the carbon copy for preparation for recitation. Four experiments a month were written up completely, rest only briefly. No copying.

Mr. W. F. Roecker, Boys Technical High, Milwaukee, Wis. Should the notebook be taken seriously in grading a pupil? Doesn't use it any more in making up grades, but relies on tests, oral and written.

Mr. Pieper. Assigns value varying from one-tenth to one-seventh to the notebook. In a questionnaire reported on at the Columbus meeting a few years ago, 83 teachers put the systematic arrangement of data, explanations and conclusions, first as the aim of the notebook; (2) fixation of essentials by repetition; (3) formulation of concepts of individual experimentation; (4) (very low) form of record; (5) record for future use.

Mr. Rivett. At Northwestern High School, Detroit, the class usually uses the first 45 minutes to work an experiment, and then the last 40 minutes are used in writing up and examination by the teacher. Classes number 24 to 30. Probably do not do as many experiments as in most other schools. Those who finish early study the text for next recitation. The slow ones come in extra time. Motivates experiments by discussion at beginning of laboratory time, or sometimes assigns it in advance. Each experiment should be approved.

Mr. Wyrick. Writing the notebook is important training for after-life. Many workers must hand in reports to their superiors, and a poor report may easily discredit good work. Pupils need the training in making reports. Grade it to show it is worth while.

Mr. R. E. Davis, Lane Technical High, Chicago, Ill. It is impossible to examine and grade notes in the laboratory if the class is large. Has notes written in the laboratory in pencil or ink, and insists on having the notes left at the end of the period. Notes must be written in good English, full enough so that a person familiar with chemistry could tell what was done, what happened, and conclusions reached. Reads and grades them as carefully as he can find time for. Special interviews with those whose notes show lack of understanding.

Digitized by Google

Mr. R. W. Osborne, Francis Parker School, Chicago, Ill. The trouble with the ordinary notebook is that the pupil knows that it will not be of any future use. The complete notebook would be valuable, as the pupil can see a future use.

Mr. G. P. Drueck, Jr., Senn High, Chicago. In addition to the laboratory notes, the notebook should contain a summary of the work in the textbook, the problems worked, and a summary of outside reading. Crowding the course into one semester as some do is not a good plan, as it does not give the ordinary pupil a chance to assimilate the matter studied. It would be better to spread it out over several years, correlating it with the other sciences, as recommended by Dr. Millikan.

Mr. Pieper. The notebook used at University High School is loose-leaf, and the experiments are indicated and numbered, to distinguish them from the other matter.

Mr. Wilson. If the notebooks are used as a basis for the tests, the pupils will save and value them.

Mr. B. W. Truesdell, Wichita High, Wichita, Kas. Have more girls than boys in chemistry classes. Should course be differentiated to suit?

Mr. K. C. Fitch, Englewood High, Chicago. Girls are segregated at Englewood, using the same text as boys, but different illustrations are brought up in class. Intend to develop different course for household chemistry when the new laboratory is ready. Less theory, little metallurgy, cement, etc., more carbon compounds and food chemistry. Did try out a special text and manual, but not satisfactory.

Mr. Truesdell. Are any schools giving a second year of chemistry? At Wichita have given a third semester course in food chemistry.

Mr. C. C. Whiteman, Froebel High, Gary, Ind. Five boys are taking second year work, qualitative analysis and sanitary chemistry.

Mr. J. M. Kurtz, Goshen Senior High, Goshen, Ind. The study of chemistry is made unnecessarily hard for pupils by the fact that we start them off with gases, and they are wholly unfamiliar with this state of matter. We ought to try to start them off with something with which they are familiar.

Mr. Tydeman. Most pupils can handle volume reduction problems if they involve only one of the laws, but get muddled when corrections are to be made for both temperature and pressure.

Mr. K. J. Stouffer, Wayland Academy, Beaver Dam, Wis. Best way is to send pupils to board and give them problems until every one is perfectly familiar with the process. Review occasionally.

Mr. Wilson appointed the following committees: Nominating Committee: H. R. Smith, Lake View High, Chicago, Ill.; L. L. Hall, Morgan Park High, Chicago, Ill.; S. A. Buckborough, Evanston High, Evanston, Ill.; Resolutions Committee: B. J. Rivett, Northwestern High, Detroit, Mich.; B. W. Truesdell, Wichita High, Wichita, Kas.; C. D. McLouth, Muskegon High, Muskegon, Mich.

IV. "Plans for Next Year's Work." Herbert R. Smith, Lake View High, Chicago, Ill. The committee on the reorganization of the teaching of chemistry presents herewith a formal report of the past year's work.

It has held five meetings with a full attendance of the committee, and four meetings with partial attendance. The chairman has met with the general committee on each of its five sessions.

Mr. Osborne has already reported on the work of the committee in formulating aims and listing principles and concepts and fundamental subject matter, and has given the results of the questionnaire, and this section has voted to approve this section of the report of the committee.

This list of fundamentals should be upheld by all possible means as

Digitized by Google

necessary to any standard course in first year chemistry. Teachers should so conduct their classes as to secure for each pupil of passing grade a fair working knowledge of such fundamentals. This list of fundamentals should be a suitable basis of knowledge for college teachers to build upon, and it should be able to function equally well in whatever vocational activities the possessor of it might attempt.

It is desirable that the list of fundamentals be kept sufficiently short to occupy no more that five or six months of the school session, in order that every teacher may be at liberty to choose further topics in the study of chemistry that may be of particular local interest. It will be desirable to expand the list of fundamentals into such detail that it may be a working syllabus for the less experienced teachers.

A list of cardinal points in the teaching of chemistry was sent out in the next letter to all who had responded to the first letter:

Methods in Teaching Chemistry:

I. Attack, or Approach of Topics.
   A. From daily life phenomena. (inductive.)
   B. From generalized statements or definitions. (deductive.)

II. Means of Approach.
   A. Through the pupil's laboratory experiment.
   B. Through the text book.
   C. Through the teacher's demonstration experiment.
   D. Through field trip observation.
   E. Through illustrative materials. (commercial exhibits.)

III. Considerations in Organizing and Presenting Material.

A. The Laboratory.

1. The pupil should know the general purpose of the experiment and have some motive for doing it.

2. A permanent record, preferably in ink, should be made as the results are obtained, together with deductions therefrom.

3. No questions should be asked in the experimental directions that require the use of a text or reference book.

4. The text book, as now constituted, should not be consulted by the pupil during the performance of an experiment.

5. While the class is at laboratory work, the teacher should be directing and assisting pupils, and not merely purveying materials.

6. The pupil's record should be corrected by himself under the direction of the teacher, and rewritten at the pupil's option.

7. It is desirable to keep the class together in laboratory work for greater emphasis. Optional work is desirable for rapid workers.

8. The pupils should be taught manipulation, cleanliness, and order in a very definite manner. This should not be incidental.

9. Some experiments are better as teacher-demonstration in order to save time and material, to teach manipulation, too difficult for pupil, and danger to inexperienced persons.

B. The Recitation.

10. The assignment should be clear and definite. It is best that careless pupils should take it in written form.

11. Pupils are prone to procrastinate. To require assignments to be prepared in written form brings a better pupil effort.

12. The lecture method is obsolete. The recitation should not be all quiz. Questions should be by pupils as well as the teacher.

C. General.

13. Topics for study should be chosen, first from a consideration of what is most fundamental; second, from local needs of pupils.

14. The above topics should consist of larger groups of ideas than

Digitized by Google

is usually presented, e. g. efflorescence, deliquescence, desiccation and sympathetic ink may well be grouped under general head, "hydrates."

15. The text book should function as a source of supplementary information not readily available by experiment.

16. The library should support the text book work, especially in regard to topics of modern importance, and arouse further interest.

17. In all science education honesty should be held paramount to all other considerations.

18. Home projects should be encouraged. Materials might be furnished at cost to pupils.

19. Science clubs are a decided help in securing pupil interest in chemistry. Where chemistry is elective they should be organized.

20. Field trips are profitable if well planned, conducted, and do not interfere with the work of other subjects.

21. What can *you* say further about method?

Fourteen replies were received which clearly showed that further discussion was necessary on this most important phase of teaching. Accordingly the Friday afternoon section meeting was shaped to afford opportunity for discussion by all chemistry teachers present at the annual meeting.

The committee further recommends that general plans be made at this meeting for trials and tests of methods by all teachers of this section during the coming year. The committee has proposed five plans, and asks that every teacher present write his name, school, address on a slip of paper, and indicate thereon which of these plans he would like to work on next year.

Testing Our Results of Teaching:

Our neighbors having gardens have expressed conflicting views as to which variety of potatoes were the best. We are quite certain that they have not considered all the factors which affect the yield.

So we quit asking our neighbors and turned to Nature, viz:

We planted five varieties the same season in parallel rows and gave each row the same cultivation. Then we knew that the yields, 40-45-60-60-80 pounds, differed by reason of the difference in variety.

While it is not so easy to test the results of our teaching, yet we can draw our conclusions from carefully collected evidence. We are exponents of the scientific method and should use more if we believe in it. Following are some plans for a more critical study of our methods of teaching:

Plan No. 1. To determine the relative efficiency of the laboratory and the teacher-demonstration methods of presenting topics to pupils.

While the laboratory method is generally accepted as the better one, yet such conditions may prevail as to largely nullify its value to pupils. In this plan direction sheets will be prepared for each pupil of one class to use after the usual laboratory plan. Then another class will take up the same subject by a prepared lecture with suitable demonstrations. Then each class will be tested by the same set of questions. This critical study of results will have a most helpful influence upon the instructor. To eliminate differences of personnel in classes the plan can be alternated with each class.

Plan No. 2. To test the relative values of a single vivid presentation of a fundamental topic as compared with the review and frequent reference plan (the spiral method).

Each plan is to be used entirely with separate classes and the results tested by an appropriate set of questions.

Plan No. 3. To test the power of pupils to apply the knowledge obtained in the study of chemistry.

Digitized by Google

A set of questions is to be devised whose correct answers will not depend on memory but upon the experience with principles. The questions will parallel the problems that the pupils have had; but will not directly suggest the principles involved in the wording of the questions, such as: How would you proceed to determine which of two elements was the most active chemically?

Plan No. 4. To determine the degree of uniformity of the training in chemistry by teachers in general.

A standard set of questions is to be adopted and supplied to all schools cooperating. They are to be used for all classes in chemistry at the end of each semester. The papers are to be reviewed by a small group of teachers, and the results tabulated.

Plan No. 5. To test the pupils progress in acquiring skill in things chemical.

The short time test, as detailed in the current number of SCHOOL SCIENCE AND MATHEMATICS, November 1919, is given to each class each week.

Query No. 1. Can we find intelligence tests that will show to us the measure of mental training that the study of chemistry affords?

Query No. 2. What is the biggest problem that you have difficulty in solving in teaching chemistry?

The writer would like any suggestions of method or helps that will insure a larger percentage of pupils coming to class each day with a faithful effort at preparation. While about to adopt a plan of assignments that require a written preparation, yet he is aware of the consequent labor of examining these daily reports and also the fact that some will copy from others.

There is more to say but it is "your move" first.

In conclusion the committee wishes to call attention to the general unsatisfactory condition of what may be called the second half of first year chemistry. As found in the average text book, it is little more than a very much condensed cyclopedia of the metallic elements, and whatever information is given is so difficult of comprehension by the pupil as to be almost valueless. In many cases the attempt to improve it by what is styled "applications" only makes the information more confusing.

The laboratory work based on the reactions of the metals leading to the study of qualitative analysis has no place in the first year's study except in technical schools where the pupil will have need of analytical skill. A group study of the metals is the only arrangement that can be justified for furnishing the pupil with comprehensive knowledge and lay the foundation for the periodic law. But this plan does not bring out the maximum interest of the pupils. The subject matter needs to be regrouped on the basis of life conditions rather than as a logically organized science. It should initiate in the life problems of the pupil rather than to try to find a connection with life after what may be, and many times is, a wearisome grind for the pupil. He should be able to see for himself the importance of the subject matter of chemistry, and not have to depend on the instructor's statement about its being important.

Herbert R. Smith, Lake View High, Chicago, Ill.
Raymond W. Osborne, Francis Parker School, Chicago, Ill.
Albert L. Smith, Englewood High, Chicago, Ill.

It was moved and seconded that the reorganization committee be continued for another year.

SATURDAY MORNING MEETING, NOVEMBER 29, 1919.

I. The committee on nominations presented the following report:

Digitized by Google

Chairman, B. J. Rivett, Northwestern High School, Detroit, Mich.; Vice Chairman, George Sype, Austin High School, Chicago, Ill.; Secretary, K. J. Stouffer, Wayland Academy, Beaver Dam, Wis. It was moved and seconded that the secretary be instructed to cast the ballot of the section for these candidates for these offices. Carried. The ballot was cast as ordered, and the candidates declared duly elected.

II. "Chemical Warfare and Chemical Teaching," Professor Wm. McPherson, Ohio State University, Columbus, O. A very interesting account of the manufacture of poisonous gases was given, and many slides shown to illustrate Prof. McPherson's remarks. The last portion of the address was a stirring appeal to all chemistry teachers to make their teaching more interesting and vital by bringing to the attention of their pupils the many applications of chemistry to war uses. Every teacher should read this article when it appears in SCHOOL SCIENCE AND MATHEMATICS.

III. "How I Improve My Chemistry Teaching," B. J. Rivett, Northwestern High, Detroit, Mich. Much of Mr. Rivett's paper has already appeared in SCHOOL SCIENCE AND MATHEMATICS, November, 1919, in his article, "Testing Results in Chemistry." Mimeographed copies of several additional tests were distributed, as well as the following list of references for those interested in this subject. The Mayman reference was mentioned as especially valuable:

Bibliography on experimentation in methods of teaching science and testing the results of science teaching:

Methods of Science Teaching:

Ayer, F. C., *The Psychology of Drawing with Special Reference to Laboratory Work*, Warwick and York, 1916. (An attempt to show that analytical drawings have value but that representative drawings are without value.)

Mayman, E. J., *Teaching Elementary Science in Elementary Schools*, Publication 13, Div. of Reference and Research, Board of Education, New York City.

Testing the Results of Teaching—Books and Pamphlets:

Monroe, W. S., *Measuring the Results of Teaching*, Houghton Mifflin and Co., Boston, ($1.60).

Monroe, W. S., *Measuring the Results of Teaching* (Revised), Riverside Press, Cambridge, 1918.

Starch, Daniel, *Educational Measurements* (Physics Tests), Macmillan Co. (Seventy-five mutilated sentences in which correct terms must be supplied).

Seventeenth Yearbook (Part II), National Society for the Study of Education (A very complete bibliography of tests in all subjects).

Army Mental Tests, Methods, Typical Results, and Practical Applications, Bureau of Education (p. 23).

Caldwell O. W., *Science Teaching in the Gary Public Schools*, General Education Board, 61 Broadway, N. Y. City.

Testing Results of Science Teaching; Articles:

Bell, J. C., "A Test in First Year Chemistry," *Journal of Educational Psychology*, Vol. 9:199-210.

Downing, E. R., "A Range of Information Test in Science," SCHOOL SCIENCE AND MATHEMATICS, Vol. 19:228-233.

Greier, N. M., "A Range of Information Test in Biology-Physiology," *Journal of Educational Psychology*, Vol. 9:210-217.

Greier, N. M., "A Range of Information Test in Biology-Zoology," *Journal of Educational Psychology*, Vol. 9:338-342.

[1]Jones, Franklin T., Union Science Tests, Tests for Physics and Chem-

Digitized by Google

istry, Published by the author, Cleveland, O.

Lackey, E. E., "A Scale for Measuring the Ability of Children in Geography," *Journal of Educational Psychology*, Vol. 9:443-451.

Randall, Chapman, and Sutton, "The Place of the Numerical Problem in High School Physics," *School Review*, January, 1918.

Webb, H. A., "Preliminary Test in Chemistry," *Journal of Educational Psychology*, Vol. 10:36-44.

Witham, E. C., "Standard Geography Test—The World for Fifth Grades," *Journal of Educational Geography*, Vol. 9:432-442.

IV. Report of the resolutions committee.

Resolved, That the Chemistry Section of the Central Association thanks the speakers for their help and inspiration and the committee on reorganization for their efforts to improve the work of this section. We consider the problem of reorganization as the most important movement undertaken in recent years. We thank especially Professor McPherson for his excellent address.

B. J. Rivett, Benj. W. Truesdell, C. D. McLouth.

It was moved and seconded that the report of the resolutions committee be accepted and approved. Carried.

V. Discussion.

Professor McPherson. O. S. U. students and faculty took the war psychological tests. Students reported low in class work by the faculty, were also found to be low in the "nut tests."

Mr. Wilson. Students at Culver Military Academy also took the army tests, and the same results were found.

The army tests have been published in full in the *Journal of Educational Psychology*, World Book Co.

The meeting was then adjourned.

HARRY M. MESS,
Senn High School, Chicago.

[1]Not an article but form tests in the process of standardization.

MINUTES OF THE GEOGRAPHY SECTION.

The meeting of the Geography Section, Friday afternoon, November 28, was called to order by the Chairman, Mr. W. F. Headley, Austin High School, Chicago. Owing to the absence of the secretary, Miss Alberta Drew, Township High School, Joliet, Ill., Miss Anne B. Royston, High Park High School, Chicago, was appointed secretary pro tem by the chairman.

The first paper was presented to the section by Mr. Andrew Nichols, Austin High School, Chicago, on "Commercial Geography as Vocational Guidance." Mr. Nichols gave an interesting survey of the many occupations which are open to a young man or woman just leaving high school, whether in office, in the mercantile field, in the world of production, or in the technical lines and professions. On account of the very diversity of occupations that are open to the young people just entering the business world, Mr. Nichols stresses the fact that students need vocational information, rather than vocational advice. He tells us that no other subject, as commercial geography, can give information which will lead the student to decide for himself what his employment may be. A careful survey of the larger relations of industrial and commercial life is the best of all preparations for business. He mentions the wonderful opportunities in Chicago for pupils to get first-hand information on subjects of commercial geography and tells how he sends representatives from his class to railroad offices, to wholesale houses, to the International Harvester Co., to study the kinds of employment which such businesses offer. These pupils make a report of their investigation to the class. In this way the class is made a

Digitized by Google

clearing house of vocational information. Industries, rather than trades, are studied. An employee has more interest in the entire manufacturing business, if he know the whole industry, rather than if he possess technical information, alone, of the operations in which he works.

"What Changes Should be made in the Teaching of High School Geography" was the subject of a paper read by Prof. W. R. McConnell, Miami University, Oxford, O. The author reminds that the aim of secondary education is for the training of good citizenship, and that geography has no place in the curriculum, unless in its study the boys and girls go through experiences that will make them better citizens. Geography has failed to secure a prominent place in the secondary school curricula, because it has not responded to educational demands. Its content and method of presentation has changed little during the last decade. Students are still memorizing facts and principles, isolated from all significance and from all relationship. A common method of teaching applied geography is to drill on geographic factors or principles of control, then go all over the world to find conditions, real or imaginary, in which principles or controls are seen in action. Factors and principles of geography may be taught by beginning with human activities, and then interpreting the activities, in the light of adjustment to geographic environment. We sometimes study mountain passes, for instance, rather than American history influenced by the Hudson-Mohawk gap.

Geography is the link between the social and natural sciences. On the side of content it belongs in a group with history, civics, political science, sociology, and commercial and industrial education. All these subjects aim at adjusting man to his environment. The basic point of view of geography is social sympathy; and genuine interest in other people, which leads to cooperation with them, has its foundation in a knowledge of their surroundings and activities.

The kind of geography needed is that which will aid in a solution of problems arising in connection with such things as industrial legislation, banking and finance, supply and demand, reciprocity, free trade, protection—all current international questions, which is fundamental preparation for intelligent and responsible citizenship.

The kind of geography to be taught in secondary schools should be neither physical nor commercial, altogether, but should be applied regional geography, a study of geographic factors that enter into the historic, economical, social life of the people of various countries of the world.

Furthermore, we should do more with the problem method of teaching. Its use is a movement in education of great significance. Educators are favoring a wise use of the problem, because it leads to the selection and disentanglement of the primal factors in a situation, and aids the teacher in bringing into focus of conscious attention basal facts and principles which would otherwise be lost in a mass of irrelevant detail. Our text books will be properly used when the material in them is made use of in the solution of some vital problem.

Mr. Chas. C. Colby, University of Chicago, in a "Presentation of Outline of Unit I, Principles of Geography," gave the following synopsis:

Central point of view:

1. Where do people live.
2. Why and how do they live there.

Forces:

1. Physical Environment	2. Social
Position—area	Race
Climate, surface	Religion
Soil, water, resources	Education

Digitized by Google

Mineral
Coast line
Plant life
Industrial development
Economic condition

Geographic Sequence:
1. Physical environment.
2. Industrial development.
3. Social conditions.
4. Political conditions
5. Density, character of population

Types of occupations:
Fishermen—Farmers

Mr Colby further suggests that we may introduce the subjects of climate, surface, drainage, soil, under titles that lie within the student's experience. For instance, "The Farmers of Illinois" may introduce a study of the plain region; "Dairy Farming in Holland" may be the title under which a delta plain may be taught.

Mr. John Calvin Hanna, Supervisor of High Schools, Springfield, Ill., read a paper on "Scope of High School Geography." He tells us that geography is an essential subject for citizenship, and that, although it is taught in the elementary school, it should find a place in the last year of high school, giving fresh information on geographic material as the student enters the careers of the world. It surely belongs there as a full unit of work, he thinks, instead of as a half unit in the ninth grade. Here, in the twelfth grade, he suggests, let it be taught as a science with practical applications. What science, furthermore, has so many practical applications, so amazingly varied? Here, as a science in the twelfth grade, let it be taught, with library studies of books and current periodicals and true laboratory thoroughness in making independent observations and drawings and recording definite conclusions.

Geography, he observes, is linked with commerce and transportation. The masters of these matters know geography and utilize it. All civic and social institutions and activities have their roots in, and their fruits determined by geography. An enthusiastic member of the Woman's Club must cram up on geography; an aviator literally "goes over the map"; the president of the church missionary society must know something of Laos, or Chosen, or the Congo, or Mesopotamia, or whatever her heart is in; he who reads the newspaper must pass an examination on a wide stretch of geographical knowledge, or must "skip it," as other stupids do, when he comes to something unfamiliar, because of his ignorance of geography.

Mrs. Gertrude Morse, Harper School, Chicago, presented in a paper what the various committees of supervisors, principals, and teachers have done in the past few years in trying to make a satisfactory course in geography for elementary schools of Chicago. She spoke of the new point of view of geography study, in which the emphasis is placed on man and his accomplishments, industrially and commercially. She further lamented the fact that the new course of study had not been well tried out on account of the lack of suitable text books and equipment.

The "Report of the Earth Science Committee of Reorganization" was given by Mr. Jas. H. Smith, Austin High School, Chicago. Unit I of his report was given by Mr. Colby in an earlier paper. In the following synopsis, he gives outlines of Unit II and III:

Unit II.

A. The Chief Commodities of Commerce.
   I. Products of the forest; lumber, rubber, cork, etc.
   II. Products of hunting and fishing: furs, fish, etc.

Digitized by Google

III. Products of the grazing lands: wool, hides, meat.
IV. Products of the farm, orchard, and garden: wheat, corn, oats, rice, rye, barley, sugar cane, suger beet. Potatoes and other root crops, and vegetables. Fruits of tropic and temperate lands. Oils, dairy products and meats.
V. Products of mines, quarries, wells.
The mineral fuels: coal, petroleum, gas.
The metals: iron, copper, lead, zinc, mercury, platinum, etc.
Clay products.
VI. Products of manufacture: power, iron and steel, textiles, foods, furniture, chemicals, etc.

B. The Movement of Commodities in World Commerce.
I. Advantage of position with reference to trade.
II. Development of great land routes of trade.
III. The great ocean routes.
IV. The organization of ocean commerce.
V. The development of market centers.

In Unit III, Commercial Countries, it is proposed to study a selected list of commercial countries, possibly grouping them as,

a. Powerful countries
b. Populous countries
c. Countries with a large commerce.
d. Countries where people live in a very different geographic environment from that of the United States.

The time required and the scope of these courses will be discussed in this program by Hon. John Calvin Hanna, Supervisor of High Schools, State of Illinois. The unit Courses will probably be adaptable to either semester of year programs. As a minimum requirement your committee agrees that, above the eighth grade, not less than one year of geography should be required of all pupils; that economic geography should be required in the ninth grade for pupils in commercial and industrial courses and elective in other courses; and that Commercial Countries should be required in eleventh or twelfth grade for all pupils in four year commercial and industrial courses and elective in other courses.

Science teachers should have in mind the legitimate demands of other subjects, and should be reasonable in their own demands. Nevertheless they should recognize the fact now made plain to all educators that much that has been taught in the past in our schools must give way to subjects of higher value. Secondary School Circular No. 3, U. S. Bureau of Education, gives as one of the five objectives of science in high schools the following:

In order to encourage high school students to elect more work in science, and at the same time to lay a foundation for a general appeal to science and its methods, every effort should be made to arouse a lively interest in science, particularly in grades 7 to 9.

During the year the committee has collaborated with two other committees working upon the same problems, namely, the committee on first year science of the Chicago high schools; and the committee on course of study in geography, of the Conference of Schools Affiliated with the University of Chicago.

The Chairman appointed a committee of nomination: Mr. D. C. Ridgely, State Normal School, Normal, Ill.; Miss Mabel Sykes, Bowen High School, Chicago; and Mr. J. M. Large, Township High School, Joliet, Ill.

On Saturday morning, Mr. W. H. Spurgin, Hyde Park High School,

Digitized by Google

Chicago, gave a paper on "Mapping by Aerial Photography." He spoke of the flyers enlarged range of vision. On a clear day, a flyer 6500 feet above Lansing, Mich., could see portions of Lake Michigan, Lake Huron, and Lake Erie. The area included in a photograph depends, of course, on the altitude of the flyer. He pointed out many short-comings of this kind of photography. For instance the top of high elevations, being nearer the camera, appear larger in the picture. High altitudes above 10,000 feet involve temperature changes which are likely to disturb the focus and retard the action of moving part. Although the aerial photographs are not accurate, they may become a valuable aid to established methods of map-making. Given a base map with a sufficient number of control points, cultural details may be gathered with amazing speed, completeness, and ease. Scarcely forty per cent of the United States has been satisfactorily mapped. Much of the detail of the remaining work may be obtained from the air. Old maps may be brought, and kept up to date. Changing coast lines may be mapped with sufficient accuracy, and as frequently as necessary. One of the oil companies with large holdings in British Columbia had spent a considerable sum exploring a mountainous region in search of a pass through which a pipe line might be run. A year ago they were considering making an aerial survey. Another improtant use of aerial photography, he suggests, is that of mapping air routes. There seems to be good reason for believing that air travel on a commercial basis, will be largely confined to definite lanes, in order to take advantage of established landing places.

Mr. F. E. Williams, University of Wisconsin, addressed the meeting on "Steps Necessary to Establish Geography as a Fundamental High School Subject." Emphasizing the importance of the subject of geography, he suggests that the first step is to get good text books. Our text books at present are inadequate. The greatest factor, however, he thinks, is in the person of the teacher. Geography cannot confine itself between the covers of any book; so it must have an especially wide awake teacher who is always on the lookout for interesting material. Too long has the class in geography, he observes, been shifted to the teacher with a free period. A teacher of average science must be a specialist through long active work in his particular study; but the geography teacher must have a background of history, dealing particularly with exploration, settlement, and progress, as well as a knowledge of soils, plants, minerals, and configuration of the land.

But no amount of specialization will ever make a perfect teacher, unless alertness, observation, initiative are there. There is a fund of information, to enrich the student's knowledge, in every periodical, dealing with world topics.

The position which geography has reached in the colleges and universities, he reminds us, is a further aid. As a high school study it should now receive an impetus from the higher institutions, where it is permanently established. The number of students taking geography in the universities has increased by leaps and bounds.

Mr. D. C. Ridgely, chairman of the nominating committee reported as follows: For chairman, Mr. Wellington D. Jones, University of Chicago; For vice-chairman, Mr. R. R. Robinson, Joliet Township High School; For secretary, Miss Anne B. Royston, Hyde Park High School.

Mr. Jas. Smith, Austin High School, introduced the subject of the appointing of a committee on propaganda, concerning the value of geography courses in high school. Mr. Williams talked in favor of such propaganda. It was moved and seconded that the retiring chairman and the new chairman of this section, together, appoint such a com-

Digitized by Google

mittee. It was further moved and seconded that this committee confer with the High School Conference of Geography of Illinois. It was moved and seconded that the reorganization committee of this section remain the same. It was also moved and seconded that the reorganization committee of the Geography Section shall continue to work with Mr. Downings' committee on reorganization.

ANNE B. ROYSTON,
Hyde Park High School, Chicago, Secretary, pro tem.

REPORT OF THE COMMITTEE ON EARTH SCIENCE IN THE REORGANIZED HIGH SCHOOL.

The work of your committee during the year has been to amplify and work out the details of the plan reported at the last meeting of the Association in November, 1918. Three Unit Courses were proposed, namely, Unit I, Principles of Geography; Unit II, Economic Geography; Unit III, Commercial Countries.

Unit I is to be presented in full by another speaker at this meeting. Therefore it is unnecessary for your committee to discuss it in this report.

A tentative outline of Unit II follows:

The Purpose, to study somewhat intimately the influence of physical environment upon man in the making of his living.

The method, a study of (a) the geographic influences in the character and location of type industries, as shown in the more important commodities of commerce; and (b) the influences determining the movement of commodities in the flow of commerce.

Synopsis of Course.

A. The Chief Commodities of Commerce.
- I. Products of the forest: lumber, rubber, cork, etc.
- II. Products of hunting and fishing: furs, fish, etc.
- III. Products of the grazing lands: wool, hides, meat.
- IV. Products of the farm, orchard, and garden: wheat, corn, oats, rice, rye, barley. Sugar cane, sugar beet. Potatoes and other root crops, and vegetables. Fruits of tropic and temperate lands. Oils, dairy products and meats.
- V. Products of mines, quarries, wells.
  The mineral fuels: coal, petroleum, gas.
  The metals: iron, copper, lead, zinc, mercury, platinum, etc.
  Clay products.
- VI. Products of manufacture: power, iron and steel, textiles, foods, furniture, chemicals, etc.

B. The Movement of Commodities in World Commerce.
- I. Advantage of position with reference to trade.
- II. Development of great land routes of trade.
- III. The great ocean routes.
- IV. The organization of ocean commerce.
- V. The development of market centers.

In Unit III, Commercial Countries, it is proposed to study a selected list of commercial countries, possibly grouping them as,

a. Powerful countries.
b. Populous countries.
c. Countries with a large commerce.
d. Countries where people live in a very different geographic environment from that of the people of the United States.

Digitized by Google

The time required and the scope of these courses will be discussed in this program by Hon John Calvin Hanna, Supervisor of High Schools, State of Illinois. The Unit Courses will probably be adaptable to either semester of year programs. As a minimum requirement your committee agrees that, above the eighth grade, not less than one year of geography should be required of all pupils; that economic geography should be required in the ninth grade for pupils in commercial and industrial courses and elective in other courses; and that Commercial Countries should be required in eleventh or twelfth grade for all pupils in four year commercial in industrial courses and elective in other courses.

Science teachers should have in mind the legitimate demands of other subjects, and should be reasonable in their own demands. Nevertheless they should recognize the fact now made plain to all educators that much that has been taught in the past in our schools must give way to subjects of higher value. Secondary School Circular No. 3, U. S. Bureau of Education gives as one of the five objectives of science in high schools the following:

In order "To encourage high school students to elect more work in science, and at the same time to lay a foundation for a general appeal to science and its methods, every effort should be made to arouse a lively interest in science, particularly in grades seven to nine."

During the year the committee has collaborated with two other committees working upon the same problems, namely, the committee on first year science of the Chicago high schools; and the committee on course of study in geography, of the Conference of Schools Affiliated with the University of Chicago.

The report given above has been worked out by these three committees sitting conjointly, under the chairmanship of Dr. Charles C. Colby.

Respectfully submitted,

JAMES H. SMITH,
Chairman.

November 28, 1919.

MINUTES OF THE GENERAL SCIENCE SECTION.

The success of the program of the General Science Section was assured at the beginning of the meeting, not only because of the excellence of the papers to be given, but also because the meeting was attended by a large number of highly representative teachers, state inspectors, and others who have contributed to the development and success of the subject. Mr. Fred D. Barber, Illinois State Normal University, Normal, Illinois, chairman of the section, presided at both the Friday afternoon and Saturday morning sessions.

The first paper was presented by Mr. S. R. Lewis, Consulting Engineer, Chicago, Illinois, on "Air Conditioning in School Buildings." Mr. Lewis gave evidence to prove that the problem of school ventilation is one of temperature regulation. As long as the air around the bodies of the pupils remains within reasonable limits of the optimum condition no tendency toward restlessness or sleepiness is exhibited. The condition of the air inspired aside from its temperature is of little moment so long as it does not carry infected dust or drops of water which may cause trouble. Mr. Lewis believes that the best method of ventilation is one which depends on the displacement of air rather than on its diffusion. An arrangement whereby an air supply will rub over the bodies of the pupils in an appreciable current at such a temperature as not to cause discomfort is the most satisfactory one. Rooms in which inlets can be under fixed seats, with outlets at the ceiling giving a slow moving updraft give excellent results. This insures ventilation by displacement and not by dilution.

Digitized by Google

Interest in Mr. Lewis' excellent paper was indicated by the discussion which was led by Mr. George Mounce of LaSalle, Illinois; Dean E. S. Keene, North Dakota Agricultural School, Fargo; Miss Mabel Spellmire, East High School, Cincinnati, Ohio; Mr. C. H. Perrine, Wendell Phillips High School, Chicago; Mr. Henry Goddard, Supervisor of High Schools, Madison, Wisconsin; and Mr. C. W. Schrock, Pontiac, Illinois. The principal points brought out by the discussion were: 1. A chemical laboratory can not be perfectly ventilated by the general system. A cabinet with an exhaust above and one below must be provided. 2. Moisture can best be introduced into the air by means of an air washer, but the engineer can not be depended upon to keep the washer in operation nor to keep it clean. Another method is to inject steam. A stationary pan of water may be used provided the area is large enough. 3. A carbon dioxide indicator is the only method for testing air. The humidity should be taken at all times.

The importance and the possibilities of giving instruction in household mechanics and a plea for more applied science in our schools were the key notes of the paper on "The Use of Physical Equipment of the School Building in Class Room Instruction," by Dean E. S. Keene, School of Mechanic Arts, North Dakota Agricultural College, Fargo. Even the most modest homes now have the conveniences of water supply, heat, and light and with them a complication of domestic mechanism. Some instruction in the operation of this machinery is essential. With the use of the equipment in the school building and the assistance of the janitor, the fireman, the plumber, and the architect information can be given in methods of heating, lighting, water supply, and sewage disposal and also in the construction and operation of the parts of each.

In the discussion which followed Mr. Keene's paper, Mr. Barber, the chairman of the meeting, said that he thought in teaching applied science one should not neglect to emphasize fundamental scientific principles. Mr. Goddard of Madison, Wisconsin, said that there has been too much of a tendency in the past to develop principles and then not to give concrete applications to fix these principles in the child's mind. "One of the best things which general science had done," Mr. Goddard added, "has been to center the thought of the teacher on the child and not on the subject matter of one or more of the highly specialized sciences."

Those who still oppose the introduction of General Science because they think that it requires an expensive laboratory, should read Prof. G. A. Bowden's paper on "Possibilities of Home Work in General Science." Prof. Bowden briefly outlined a course, all of the projects of which centered around the home, for example, lighting the home, heating the home, weather and climatic conditions about the home, and others. He then developed one or two of these projects and showed their possibilities for home work. Throughout the course, Mr. Bowden finds the desire on the part of most of the pupils to make or repair something in the home. This gives new material for study, such as repair of a thermostat, construction of a fireless cooker, wiring, arrangement of switches and lamps so that lights may be turned on at the house and off at the garage, etc. Another agent which he finds valuable is a portable projecting lantern with slides and post card pictures. He allows pupils to select sets of slides and pictures bearing upon some topic under discussion and to take them together with the lantern to their homes. The pupil who takes the lantern home that evening gives the family an illustrated lecture. Mr. Bowden does not believe that the work of the

Digitized by Google

course should be confined to the home. Many problems should be given in the laboratory and in the class room.

Mr. George Mounce, LaSalle-Peru Township High School, LaSalle, Illinois, in his paper on "Some Tangible Results from a Course in General Science", emphasized the fact that the course in general science is the first opportunity which the boy and girl have had to get knowledge about the things in their environment: automobiles, kites, telephones, and the many other things which arouse a child's curiosity. The first and most important result of a course in general science is thus the creation of a boundless enthusiasm for the wonders of science. This gives the impulse which starts many pupils to reading scientific books and to investigation on their own accord. After the introduction of the course in general science, Mr. Mounce found a steady increase in the numbers of students electing the advanced sciences and also an improvement in the quality of the work done in those subjects.

After a brief discussion of this paper, the chairman appointed the following nominating committee: Mr. H. N. Goddard, Supervisor of High Schools, Madison, Wisconsin; Mr. C. E. Spicer, Joliet Township High School, Joliet, Illinois: Miss Mabel G. Spellmire, East High School, Cincinnati, Ohio.

The report of the committee on reorganization was given by Miss Ada L. Weckel, High School, Oak Park, Illinois. This committee sent out questionnaires to determine the aims of general science, the basis for the selection of subject matter, the units of subject matter, the organization of subject matter, and the use of the project method in presenting the subject. In the replies received, the problem seeing and the problem solving aim was given first choice; the appreciation aim second; and the knowledge aim third.

All agreed that the selection of subject matter should be made on the basis of facts, principles and concepts which everyone should know for his own personal welfare and on account of his social relations. About eighty per cent approved of segregation in schools of sufficient size with a selection of materials in part for (1) boys, (2) girls, and (3) as bearing on the intended vocation.

The following units of subject matter were approved by at least seventy-per cent of the teachers who replied. The units are listed in the order of choice: 1. Principles and systems of ventilation. 2. Principles and systems of residence and school room heating. 3. Sources, nature, composition and combustion of common fuels. 4. Residence and school room heating, artificial and natural. 5. Hygiene and sanitation, principles and practice. 6. Weather, including air, physical properties and mechanics of gases. 7. Microorganisms as related to foods, to decay, to soil, to health. 8. Water supply and sewage disposal, including household plumbing. 9. Mechanics as related to home and street life, "safety first." 10. Electricity and magnetism—dry cell, door bell, house connections and wiring. 11. Climate in its relation to health, and to plant and animal life.

The two following units were approved by 57 per cent:

1. English and metric systems of measurement. 2. Steam engines and gas engines.

Only 37 per cent approved of:

1. Human anatomy and human physiology as such.

Over 75 per cent expressed their preference for the organization of the subject matter in general science around natural units such as are given above, rather than around units composed of materials which are scientifically related, as is common in special sciences.

Digitized by Google

Replies indicated a diversity of opinion relative to the use of the project method in general science, some thinking it should be used exclusively, others in part, others not at all, and still others were undecided.

After a discussion of this report and the work to be undertaken by the committee during the coming year, Mr. Goddard, Madison, Wis., moved that the committee appointed last year by this section be continued for another year and that this committee be asked to formulate a plan of general science for the ninth year (first year of four year high schools) based on the project idea, and further that this plan be presented to the section in the form of a written report at the meeting of the section next year.

This motion was seconded and approved. The members of the committee on reorganization are: Mr. Fred Barber, Normal, Illinois, chairman; Mr. Ernest Collette, Chicago, Illinois; Miss Ada L. Weckel, Oak Park, Illinois.

The meeting was adjourned until 10 a. m. the next day, November 29.

The section was most fortunate on Saturday morning to have the benefits of the good judgment and long experience of Prof. Herbert Brownell, University of Nebraska, who read a paper on "The Role of Laboratory Work in General Science and the Teacher Training It Involves." After twenty-six years of training teachers for secondary schools, Prof. Brownell says that he has been unable ever to find any satisfactory substitute for the laboratory in science teaching. He strongly urges the use of carefully prepared laboratory manuals, especially in general science, which subject, he says, if taught without well defined and well sustained laboratory features fails to function properly in public school education. Trained science teachers of long experience in large city systems can well be left to choose and combine and use successfully material of their own science courses. But Prof. Brownell urges that those who are earnest advocates of the value of general science should not be blind to the fact that the future of the subject is determined largely by teachers who lack experience, teachers in the smaller high schools. In regard to the teacher, Prof. Brownell finds that the demand is no longer for teachers who have specialized in some one science. School boards are insisting on having teachers who possess general knowledge in all the fields of science.

Mr. E. B. Collette, Lake View High School, Chicago; Mr. G. A. Bowden, Cincinnati, Ohio; Mr. W. F. Roecker, Boys' Technical High School, Milwaukee; Mr. R. A. Denslow, Cicero Township High School, Berwyn, Illinois; and Mr. D. W. Lott ,Cleveland, Ohio, took part in the discussion which followed Prof. Brownell's paper. With the exception of Mr. Lott, all expressed themselves in favor of laboratory work, but not of the formal type. Mr. Lott preferred to have some formal laboratory work. Prof. Brownell thinks that the type of laboratory work given should depend upon the teacher. Some get better results with a formal type, others with a less rigid type.

Mr. John Calvin Hanna, State Supervisor of High Schools, Springfield, Illinois, presented an excellent paper on "The Place of General Science in the High School." Mr. Hanna was one of the first men to whom the idea of general science occurred, and he has fostered and watched with interest its development through a long period of years. After these years of observation he has come to the following conclusions: 1. General science has a legitimate place in the high school. 2. It should, if offered at all, be required of all students. 3. The course should be a full time one-year course, with at least one double period a week given to laboratory work performed by the pupils themselves. 4. It should be organized

Digitized by Google

with special reference to the pupil's degree of maturity, as a basis for further study and as a real introduction to the whole field of science. 5. It should come first—before the study of the other sciences. That is, it should be taken in the ninth grade. In the junior high schools it might be so organized as to run through seventh and eighth grades.

Mr. Hanna objects to the introduction of a two-year course in general science on the ground that there is not time for it. He approves, however, of two prescribed units in science, the first general science and the second one of the special sciences.

Much interest was manifested in the discussion which followed Mr. Hanna's paper, especially in the effort to determine the prescribed units in high schools. And as Mr. Hanna pointed out, most high schools are small, small high schools can not offer electives, so for the majority of pupils in the State, most of the units are required. Although, as specialists, we prefer more than two units of required science, it was evident with the claims made by other subjects that we could not hope for much more.

Prof. A. W. Nolan, State Supervisor of Agricultural Education, Springfield, Illinois, gave an interesting paper on "General Science and Vocational Education" We were interested to learn that an advocate of vocational education finds a real value in general science. In all vocational education there are three phases of instruction to be followed out. These phases Prof. Nolan termed "the three r's"—rules, reasons, and related studies. It is in the last two aspects of study that general science functions as a reference study, to give reasons, explain principles and to lead into related matter. Mr. Nolan believes that any of our standard texts may be used as a constant source of excellent reference material to give principles and enriching related studies for all the manipulative processes in the jobs of major vocations. He further thinks that in all vocational courses, general science should be required early in the course. It should precede or parallel the vocational courses for one or two years.

The nominating committee submitted the following report: Chairman, G. A. Bowden, University High School, Cincinnati, Ohio; vice-chairman, George Mounce, La Salle-Peru Township High School, La Salle, Illinois; secretary, Ruth C. Russell, Lake View High School, Chicago, Illinois.

The secretary was instructed to cast a unanimous ballot for persons whose names were submitted.

The interest shown in the meeting of the Section of General Science was such that the future of this new section of the Association seems assured. The section adjourned.

ADA L. WECKEL, *Secretary*,
High School. Oak Park, Illinois.

MINUTES OF THE HOME ECONOMICS SECTION.

On Friday, November 28, Dr. Blunt, of the University of Chicago, opened the meeting and presented Miss Trilling, also of the University of Chicago, as chairman, who outlined the work of the Reconstruction Committee of home economics. She showed how several committees had pooled their results of their investigations under the following heads: 1. Methods used in making surveys; 2. Results of these investigations, showing present status of (1) methods, (2) aims, (3) generalizations; 3. Suggestive changes in methods, aims and concepts; 4. The use of standardized tests.

Miss Helen Goodspeed, State supervisor of home economics, Wisconsin, gave as the State slogan, "Come out of the basement"—come out in body and spirit. Her statement of aims, derived from surveys was to

Digitized by Google

develop (1) skills (technical); (2) general ideas—judgments, etc.; (3) information; (4) Problem-solving ability. She submitted the following as possible aims: Training for active membership in home and community; training in power to see and to solve problems; training in appreciation of various phases of home making and in development of judgment in regard to these; sufficient training in skill to develop thorough appreciation and understanding to the end that these skills may be perfected, when desired, in home environment.

The lines of action suggested were the training of teachers for four years; placing more background of history, science, English, economics, etc., in the course of study and emphasizing home project work; accepting problem-solving method of teaching; having instructors in teacher-training schools visit in the field so as to make theory and practice one.

Nominating committee was appointed, by chairman composed of Miss Florence Williams, Richmond, Indiana; Miss Falls, Lake View High School, Chicago; Miss Helen Goodspeed, Wisconsin.

"Tests as an Aid in Formulating Course of Study" was given by Miss Florence Williams, of Richmond, Indiana.

Surveys showed weaknesses in choice and use of text books; choice and development of materials; distinction between high school and grade problems. General results from tests are: A series of promotions and demotions; change in size of classes; change in content of course; change in method; change in time allowance.

Discussion was led by Miss Emily Frake of Parker High School, Chicago, who gave some of her personal experiences in problem-solving method. She gave the value of tests as a help to the teacher in checking up on herself, and as a help in stating definite aims.

Miss Rosa Biery, of the University of Chicago Elementary and High Schools, spoke on "Economics in Home Economics Courses." She gave the following phases of economics as those which she has found valuable in junior and senior high-school classes: 1. The effect of changing economic and industrial conditions upon home life and upon women; 2. The influence of women and girls as spenders in furthering economic prosperity of the world; 3. The attitude of searching out facts concerning things the weighing of values.

The speaker showed how she made use of these phases in the presentation of work in the high school, largely by the problem-solving method.

Meeting adjourned until Saturday, ten a. m.

IVAH M. RHYAN,
Head of Home Economic Department, Terre Haute, Ind., Normal, Secretary pro tem.

On Saturday, November 29, at 10:30 a. m., Miss Blunt, of the University of Chicago, presided.

Miss Falls of Lake View High School read the following report for the nominating committee: Harriett Glendon, Lewis Institute, chairman; Treva E. Kauffman, Columbus, Ohio, vice chairman; Maude M. Firth, Davenport, Iowa, secretary. The report was accepted as read.

The section voted that the new chairman appoint some one from the section to serve as chairman of a committee on membership, cooperatind with the membership committee of the whole association.

It was moved that a vote of appreciation to the reconstruction committee for the work they had done during the past year be recorded. Carried unanimously.

Following this, Miss Minnie L. Volk, of South H. S., Columbus, Ohio, read a paper "The Correlation of Art and Household Art," in which she urged the necessity for art in all public schools as an integral factor in the

Digitized by Google

process of socialization. Art training comes not only from the actual drawing itself, but from the unconscious training which comes with good surroundings in class rooms, school grounds and the community in general.

Drawing in itself should be subordinated to the teaching of laws of harmony, color, balance, unity. Costume design is one very important means of teaching art in the high school. The aim of the costume design in South High School is to develop good taste, acquire a knowledge of the evolution of line in costume, the use of appropriate and becoming materials, styles and colors. As a result of the teaching of costume design, there is a marked change in taste in dress among the girls of the high school. The students take charge of the costumes in the dramatics given by the high school.

The next paper, "The Value of Animal Experimentation to the Human Family" was read by Miss Emma Francis, of Battle Creek Sanitarium, Battle Creek, Michigan, and accompanied by an extensive exhibit of rats fed on different experimental diets.

Animal experimentation has taught us that we cannot choose our food indiscriminately from our abundant store. Many valuable constituents are wasted and lost in processes of manufacture and preparation.

In the laboratories of the Battle Creek Sanitarium they are endeavoring to find the lack in the vegetarian diet fed to rats by Slonaker of Leland Stanford University as early as 1908, on which the rats had failed to grow as they had on an omniverous diet. The food combination consists of cracked corn, cooked corn, bread, almonds, lettuce, baked beans, muffins, mashed potatoes, macaroni, oatmeal and buckwheat cakes.

To determine the inadequacy of such a diet, the following additions were made: (1) butter fat; (2) butter fat and fifteen per cent soy bean for complete protein; (3) butter fat and fifteen per cent soy bean and fifteen per cent mixture of greens. The addition of butter fat has given no better growth than the original diet. The second addition (butter fat and soy bean) increased the weight slightly and improved the appearance of the tail. The butter fat, soy beans and greens caused half the animals to double in weight in a month and the others are making normal gains and all are in fine condition.

Animals on diets with and without milk have been found valuable aids in illustrating talks to school children and to mothers concerning the value of milk for young children. The addition of one tablespoonful of milk a day to a diet consisting of potatoes, greens and bread causes two to three times as much growth as was obtained without the milk, and this one tablespoonful was thought to correspond to the cupful of milk a child might get with his school lunch.

Discussion of this paper was postponed until after the next paper by Miss Mary E. Freeman of the Chicago Public Schools, "Malnutrition of Children and What the School Can Do to Overcome it."

The responsibility for getting nutrition information across to the children and mothers lies chiefly with the elementary school teacher by virtue of the fact that she has both boys and girls under her supervision and has them for more periods a day or week than the home economics teacher, which gives her opportunity to correlate the nutrition work with her daily lessons.

In this particular instance, the grade concerned was the sixth. The children's interest in nutrition was caught and held by the fact that there were 27 days of absence the first month and 55 the second. The children decided for themselves that sickness was the only legitimate cause of absence and made the natural opening for the discussion of what a child must do to keep well. In one month's time, the breakfasts and hours of sleep had noticeably improved as shown by daily reports.

Digitized by Google

Very definite training in proper habits of eating and living can thus be given the children, without even scales or measuring rods, if the elementary school teacher sees the opportunity before her and is sufficiently trained to take advantage of it.

The discussion was led by Miss Jenny Snow, of Chicago, who emphasized the need of at least one course in home economics for every elementary school teacher. Many nutrition classes are now being conducted in the Chicago public schools and the Infant Welfare Society has eight such classes.

At this time, Mr. Newbill, of the States Relation Service, and in charge of the boys' and girls' club work, spoke for a few minutes concerning the value of such club work in developing citizens.

Meeting was adjourned.

SYBIL WOODRUFF,
Secretary pro tem.

MINUTES OF THE MATHEMATICS SECTION.

The Mathematics Section held two meetings, on November 28 and 29, 1919.

FRIDAY AFTERNOON MEETING.

In the absence of the chairman, Mr. Byron Cosby, of Kirksville, Mo., Mr. Marquis J. Newell, of Evanston, Ill., presided.

Prof. C. A. Epperson, of State Teachers' College, Kirksville, Mo., read a paper on "Some Problems for the School Room from the Orientation Work of the A. E. F." In this address Prof. Epperson spoke of the great difficulty encountered during the war in finding persons who knew enough about simple trigonometry to solve right triangles by means of logarithms. He said that usually one who could solve quadratic equations and use logarithms would be sent to an officer's training camp. This may indicate either that we teach insufficient mathematics or that what we do teach does not function. Prof. Epperson urged that we give more thorough training in accuracy in computation and put more emphasis upon the use of the co-ordinate system. Several problems derived from the field of orientation were cited as especially valuable for such training. In a digression from his main topic, Prof. Epperson spoke of the great advantages of the metric system and called attention to the fact that all of the men who have been in France would now favor a change from our present system to the metric system.

Mr. J. A. Foberg, of Chicago, Secretary of the National Committee on Mathematical Requirements, read the preliminary report of a subcommittee of the National Committee on "The Reorganization of the First Courses in Secondary School Mathematics." The report covers the work of the first two years of the standard four-year high school. The following two principles are made the basis of the discussion: 1. The primary purpose of the teaching of mathematics should be to develop the power of understanding and analyzing relations of quantity and of space which are necessary to an understanding of the world, and to develop the habits of mind which will make this power effective in the life of the individual; 2. The courses in each year should be so planned as to give the pupil the most valuable mathematical information and training which he is capable of receiving in that year without reference to the courses which he may or may not take in succeeding years.

The report states that the one great idea which is sufficient in its scope to unify the course is that of the functional relation. The report urges "that continued emphasis throughout the course must be placed on the development of power in applying ideas, processes, and principles to

Digitized by Google

concrete problems, rather than to the acquisition of mere facility or skill in manipulation." Hence most of the emphasis now generally placed on the formal exercise should be shifted to the concrete or "verbal" problem. Instruction in numerical trigonometry is insisted on, while in geometry informal work of an intuitive, experimental and constructive character should precede work in formal demonstrative geometry.

The discussion of this report was opened by Mr. Charles Ammerman, of the McKinley High School, St. Louis, Mo. Mr. Ammerman stated that while in general he was in hearty agreement with the report that he wished for a discussion of first, the organizing idea of the subject and second, the modification of topics. He urged that we give fewer notions but make the pupil thoroughly conversant with them, but questioned whether the idea of functionality should be one of those introduced.

During the general discussion which followed, the following persons participated: Mr. C. E. Comstock, of Peoria; Miss Marie Gugle, of Columbus, Ohio; Mr. H. C. Wright, of Chicago; Miss Ethel Jaynes, of Chicago; Mr. Collins, of Wisconsin; Mr. W. D. Reeve, of University of Minnesota; Miss Mabel Sykes, of Chicago; Mr. J. O. Hassler, of Chicago; Mr. W. E. Beck, of Iowa City, Iowa; Dr. H. E. Slaught, of the University of Chicago; Mrs. Mary Devereux, of Chicago, and Dr. H. O. Rugg, of the University of Chicago.

The following resolution introduced by Mr. J. R. Clark of Chicago Normal School was adopted:

Whereas, the preliminary report submitted to the Mathematics Section of the Central Association does so thoroughly reflect the modern and progressive tendency in mathematical education, and

Whereas, the need for a sound, thorough-going reorganization in mathematics courses is so generally recognized, and

Whereas, the weight of opinion and prestige of this body of teachers will go far toward ushering into general practice these progressive ideas, therefore be it

Resolved, That we, the Mathematics Section of the Central Association, do heartily endorse the general point of view of this report, and be it further

Resolved, That we pledge our individual and group cooperation with the National Committee by reporting our personal criticisms, (recommendations for omissions and additions to the report) in writing, to some member of the National Committee.

Mr. C. M. Austin, of the Oak Park High School, then discussed "The Organization of a National Council of Secondary Mathematics Teachers." He pointed out the lack of any organized body of mathematics teachers meeting at the time of the annual meeting of the Department of Superintendence of the N. E. A. There is a real need for such an organization to act as a coordinating force to bring together all interests and to present them before the teachers and the administrators of the country who have the power to make out courses of study. After canvassing the opinion of prominent teachers of mathematics in the country, letters were sent to the mathematical organizations asking them to appoint delegates to the N. E. A. meeting at Cleveland, Ohio.

Mr. W. W. Gorsline, of Crane Technical High School, of Chicago, moved "that this section endorse the movement of organizing a National Council of Secondary Mathematics Teachers of America and that the chairman of their section select from this group three to five members to attend this meeting as our delegates. This was seconded and carried but later it was moved, seconded and carried that the number of delegates should be five.

Digitized by Google

Dr. H. E. Slaught spoke in favor of such an organization and urged all who could do so to attend the meetings.

Mr. Newell then appointed the following nominating committee: Mr. E. L. Thompson, Joliet, Ill.; Miss Mabel Sykes, Chicago, Ill.; Mr. J. O. Hassler, Chicago, Ill.

It was moved by Miss Mabel Sykes that a committee be appointed to make a list of the mathematical processes needed in certain lines of work. This was seconded and carried.

The section adjourned.

SATURDAY MORNING SESSION.

At the Saturday morning session, Mr. W. D. Reeve, of the University High School, University of Minnesota, discussed "The Classification of Students According to Ability Shown in Psychological Tests and a Study of Subsequent Records." This report is not a final one as the experiment is not yet concluded, but Mr. Reeve is confident that children should be classified according to some test of high reliability. The report was discussed by Miss Mabel Sykes, of Chicago, Miss Ethel Jaynes, of Chicago, Mr. Comstock, of Peoria, and Mr. F. C. Touton, of Teachers College, Columbia University.

The nominating committee submitted the following report: For chairman, Mr. M. J. Newell, Evanston, Ill.; for vice chairman, Mr. W. E. Beck, Iowa City, Iowa; for secretary, Miss E. G. Parker, Oak Park, Ill.

The report was accepted and the chairman of the committee instructed to cast a ballot for the persons nominated.

The following delegates to represent this section at the first meeting of the National Council of Secondary Mathematics Teachers at Cleveland, Ohio, were appointed: Dr. H. E. Slaught, University of Chicago; Miss Mabel Sykes, Bowen High School, Chicago; Mr. W. W. Hart, University of Wisconsin; Mr. C. E. Comstock, Bradley Polytechnical Institute, Peoria, Ill.; Mr. W. E. Beck, High School, Iowa City, Iowa.

Mr. Newell read a clipping from one of the Chicago papers which gave an erroneous report of the Friday afternoon session. Mr. J. R. Clark, of the Chicago Normal School, and Mr. Wehrmeyer were asked to write a reply correcting this statement.

The session adjourned at noon.

ELSIE G. PARKER,
Secretary.

MINUTES OF THE PHYSICS SECTION.

The meeting was called to order by chairman Fred R. Gorton, of Michigan State Normal School, Ypsilanti, and proceeded to take up the regular program.

"Preliminary Intelligence Testing in the Department of Physics, University of Chicago," Dr. Harvey B. Lemon: The notable increase in the attendance in all departments at the University has been especially marked in the physics and chemistry departments. Thus in the present year in the junior college in eight physics courses there are or will be 36 sections of about 24 students each, meeting nine hours per week.

Under these conditions it seemed the part of wisdom to test the ability of all those beginning the subject so as to eliminate probable failures at the start. At the first meeting of the classes, a form card is filled out by each entrant, which gives: Name; age; university classification; year in university; high school physics taken; when; where; what text book; previous mathematics in high school; in college; previous science courses in high school and college; other courses being taken simultaneously with present course; why is the student now registered for this particular course?

Digitized by Google

At this first session an efficiency test is also given. Questions are dictated and answers are written at once with only a brief time for thought or computation. These questions cover high school physics with some arithmetic and algebra. For example: How much current does a 50 watt lamp consume on a one hundred volt circuit?

What is Boyle's law?

How many degrees below zero is absolute zero, and why this number?

$(m+x)$ $(m-x)$

Reciprocal of $2/7$.

Solve $3 : 12 = 16 : x$.

Reduce .395, .005 to percentage.

If PV is constant how is P affected by doubling V?

Equation, $y = ax - b$. Solve for x. What is y equal to when $x = 0$?

Students who show averages below fifty per cent have their records carefully scrutinized and all then interviewed. Many at once agree that it is wise for them to drop the subject, while others protest and are sure they can carry the work. No one is compelled to drop out. Out of 171 taking the test this year, forty were below fifty per cent; twenty-two of these agreed that they were not properly prepared and at once entered some other class. Of the remaining eighteen who insisted on going on, nine failed in the first four weeks, while the other nine all were making good.

Almost none of those passing the efficiency test with marks above fifty per cent have proven unable to carry the work, so far as preparation and ability is concerned.

Records are being kept so that in a few years it can readily be ascertained how the different high schools sending students to the university rank in these tests; and special effort will be made to cooperate as as to secure the greatest possible benefit to all concerned.

"Some Everyday Applications of Acoustical Principles," F. R. Watson, University of Illinois: One of the everyday axioms concerning fishing is not to talk. "Don't talk or you'll scare the fish" is the usual statement. Theory shows conclusively that sounds generated in the air are almost totally reflected on reaching the water. Experiments made while fishing show that it is not the noise of talking but noises produced when they are transmitted to the water that scare the fish. Sitting still in the boat and talking loudly produced no effect on nearby fish, but the slightest scraping of the feet on the bottom of the boat sent them scurrying away.

An interesting and perhaps valuable application of diffraction has been made by the author[1] following some experiments made by Lord Rayleigh.[2] A megaphone with a rectangular aperture about 2 in. by 6 in., when held with this "slit" vertical spreads the sound waves vertically but scarcely affects their horizontal spread dispersion. This megaphone is well adapted to addressing a crowd on bleachers at an athletic meet as the sound waves will be carried to all the bleachers at once.

"The Automobile in Physics," H. C. Krenerick, Milwaukee, Wis.: Practically every principle in mechanics, heat and electricity finds some illustration or application in the automobile. Attempts to use the automobile in instruction by means of cuts and slides proved its value for this purpose, but the results were so unsatisfactory that it was decided to get the real thing.

[1] *Physical Review*, Vol. II, page 244, 1918. *Scientific American*, May 24, 1919.
[2] *Philosophical Magazine* Vol. 6, page 289, 1903.

Digitized by Google

After many months of effort and disappointment a 1917 model roadster was secured, the body removed and the chassis completely torn down, cleaned and reassembled in my laboratory. With a hack saw portions of the castings and housings were cut away so that the action of every part was clearly visible. The different parts of the machine were painted distinctive colors so that the tracing of the fuel supply system, electric wiring, etc., could be easily followed.

Thus far, the value and interest of the work which has been done with this car have been extremely gratifying. Further experience will doubtless increase its usefulness.

"The Use of the Electron in Elementary Physics," Daniel L. Rich, University of Michigan: In spite of the universal belief in the electron theory, and a considerable knowledge of the subject by all physicists, almost none of the elementary textbooks in physics make any use of that theory in explaining simple electrostatic and magnetic phenomena. The use of the electron in elementary science is attended with no greater difficulties than the use of atoms and molecules, and such use will certainly clarify, and simplify much that the older methods of explanation leave out.

The idea of the electron should be introduced at the very beginning of the study of electricity; preferably in the simpler phenomena of electrostatics. The notion of the neutral atom with its central, positive nucleus and surrounding mobile, negative electrons; positive and negative charges due to loss and gain of electrons; attraction between nucleus and electrons but repulsion between electrons; transfer of electrons through conductors but not through insulators, all these are most readily grasped by the high school student.

Similarly the electric current as a flow of electrons is not only scientifically accurate, but much more tangible, and easier of comprehension than any other notion. A clear understanding of electrical potential is perhaps impossible to young beginners, but there is no more need of emphasizing electrical potential than gravity potential. The analogy between electrical pressure and water pressure is so close that it may be sufficient to speak of electrical pressure under all conditions and leave the term potential for more mature consideration.

The assumption of a magnetic field around a moving electron immediately connects magnetic and electro-magnetic phenomena, and permits a clear picture of how a piece of iron is magnetized by bringing the orbits of the electrons in parallel planes.

The electron won't explain everything, but the difficulties it presents are not so numerous as those presented by older theories; and when it can be used it results in an explanation readily plausible and intelligible to even a beginner.

"Testing a Class for Color Blindness," Chas. M. Turton, Bowen High School, Chicago: The lack of a lantern made it impossible for Mr. Turton to present the method as he had intended, so he contented himself with a very brief explanation and a statement of his results. He had found no unmistakable cases of color blindness in some two hundred pupils tested.

Report of the Reorganization Committee, A. W. Augur: In response to the questionnaire sent to two hundred physics teachers fifty-eight replies were received. First choices were as follows: Ability aim, 30, or 51.7 per cent; knowledge aim, 15, or 25.9 per cent; appreciation aim, 13, or 22.4 per cent. The votes on the seven unclassified aims agreed very well with this vote: Initiative, 29.8 per cent; logical thinking, 22.8 per cent; appreciation of environment, 22.8 per cent; scientific attitude,

Digitized by Google

10.5 per cent; information, 3.5 per cent; science of physics, 5.3 per cent; moral law, 5. 3. per cent.

The next step will be to secure a vote on the subject matter of a standard course in physics, and to devise methods of testing results obtained by the different methods of instruction. There will also be an earnest effort made to encourage the trying out of new methods.

In accordance with the recommendation of the chairman, three committees were appointed to take up these three lines of work for the coming year:

I. To determine subject matter of course, C. L. Vestol, Chicago, Chairman.

II. To supervise and suggest experimentative in methods, H. C. Krenerich, Milwaukee, Chairman.

III. To suggest tests to determine how far physics teachers are realizing their aims, Fred R. Gorton, Ypsilanti, Mich., Chairman.

These chairmen were authorized to select additional members of their committees.

Officers for the ensuing year were elected as follows: Chairman, H. Clyde Krenerich, N. D. H., Milwaukee; vice chairman, Chas. T. Phipps, State Normal, DeKalb, Ill.; secretary, Glenn W. Warner, Englewood High, Chicago.

Adjourned.

A. W. Augur,
Secretary.

CLASSROOM SAYINGS.

What is a nebula?

One kind of nebula is a nebula hypothis.

What is centrifical force and give an example?

A centrifical force is one equal all around, when hitting a ball the force on it is ever the same until it lands.

Scientrific force is that which changes size and shape of a body as the spring balances the weight changes the shape and size of the spring.

Scientifical force is that which does not require the energy of man for example electricity.

Centrifugular force is a force acting on one point called the center such as the works of a clock or automobile.

Cyntrivical force is a force that goes around a certain axis. The electric fan for example.

Saturated air is air that has been raised to boiling and exploded into vapor.

The artic circle bounds the fridget zone.

A screw is an inclined plane with treads on it.

When melted sulfur gets very hot it becomes vicious (viscous).

A river drops waists and makes furtal land. It also makes leveys and a terrass.

Sublimation is when a solid changes to a gas in the form of a liquid.

Moisture gets into the air by evaporation, respiration and sublimation.

The principle of dry farming is that they put a dry place on the wet soil.

Here's a good one from the classical department:

Our classical head was explaining the meaning of "metempsychosis" or the transmigration of souls, in connection with the sixth book of the Aeneid.

After listening awhile, one of the seniors piped up and asked:

"Is that the same thing as the Feudal System?"

Digitized by Google

PROBLEM DEPARTMENT.

Conducted by J. O. Hassler,
Crane Technical High School and Junior College, Chicago.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. If you have any suggestion to make, mail it to him. Address all communications to J. O. Hassler, 2337 W. 108th Place, Chicago.

SOLUTION OF PROBLEMS.

631. *Proposed by R. T. McGregor, Elk Grove, Calif.*

If $a : b = c : d$
Show that $a^4d^4 - a^3b^3d^4 + b^4c^3d^3 - b^4c^4 = 0$

I. *Solution by William H. Brown, Amherst High School, Amherst, Mass.*

$ad = bc.$
$\therefore a = bc/d.$
Substituting:
$(bc/d)^4d^4 - (bc/d)^3b^3d^4 + b^4c^3d^3 - b^4c^4 = b^4c^4 - b^4c^3d^3 + b^4c^3d^3 - b^4c^4 = 0.$

II. *Solution by N. Barotz, New York City.*

Let $a/b = c/d = k$
Then $a = bk$ and $c = dk.$
Substituting these values in the given equation:
$b^4k^4d^4 - b^4k^3d^4 + b^4k^3d^4 - b^4d^4k^4 = 0.$
$0 = 0.$

Also solved by ANNABEL DONNELLY, HAZEL C. JONES, J. S. MORRIS, H. L. NEHER, A. PELLETIER, CLYTUS ROBINSON, HENRY RUZICKI, M. G. SCHUCKER, T. F. TYLER, OSCAR M. TOGLE *and* HERBERT C. WHITTAKER.

632. *Proposed by Walter R. Warne, Carlisle, Pa.*

Determine k so that one root is twice the other in
$$(2k-1)x^2 + (k+3)x + (k^2 - 2k + 1) = 9.$$

I. *Solution by N. Barotz, New York City.*

Solving the general quadratic equation and placing one root equal to twice the other:
$(-b + \sqrt{b^2 - 4ac})/2a = (-b - \sqrt{b^2 - 4ac})/a.$
Therefore $2b^2 = 9ac.$
The corresponding values in the given equation have the same relation, if one root is to be twice the other.
$$2(k+3)^2 = 9(2k-1)(k^2 - 2k - 8)$$
$$18k^3 - 47k^2 - 138k + 54 = 0$$
$$k = .354; 4.253; \text{ and } -1.997.$$

There was an error in the statement of this problem. The second member of the equation should have been zero. By coincidence, the author of the solution below has made the opposite mistake and solved the problem as submitted to the editor by the Proposer.—*Editor.*

II. *Solution by Herbert C. Whitaker, Philadelphia.*

If one root of the quadratic $ax^2 + bx + c = 0$ is twice the other root, then $9ac = 2b^2.$
Hence substituting the given coefficients:
$$9(2k-1)(k^2 - 2k + 1) = 2(k+3)^2$$
Which reduces to
$$18k^3 - 47k^2 + 24k - 27 = 0.$$

Digitized by Google

Which can be arranged

$$(k-2.31505)(18k^2-5.3291k+11.6629) = 0.$$

The only real value of k is 2.31505

and the roots are

$$-3c/b = -.97611$$

and

$$-3c/2b = -.48805.$$

Also solved by J. S. MORRIS, A. PELLETIER, *and* M. G. SCHUCKER.

633. *Proposed by N. P. Pandya, Amreli (Kathiawad), India.*

Draw a straight line bisecting each of two coplanar triangles. Under what circumstances will its intercepts within the triangles be equal?

No solutions to this problem were received.—*Editor.*

634. *Proposed by Herbert C. Whitaker, Philadelphia, Pa.*

Find the value of $(-\pi)^{\pi}$.

I. *Solution by the Proposer.*

$$\begin{aligned}(-\pi)^{\pi} &= \pi^{\pi}(\cos\pi+i\sin\pi)^{\pi}\\ &= \pi^{\pi}(\cos\pi^2+i\sin\pi^2)\\ &= 36.4625(\cos 9.8696+i\sin 9.8696)\\ &= 36.4625(\cos 565°29'+i\sin 565°29')\\ &= -32.915-15.688i\end{aligned}$$

II. *Solution by Norman Anning, Orono, Maine.*

$(-\pi)^{\pi} = \pi^{\pi}(-1)^{\pi}$ = tensor × versor.

Now $(-1) = e^{(2k+1)i\pi}$ where $k = 0, \pm1, \pm2, \pm3, \pm4$, etc.

$$\begin{aligned}(-1)^{\pi} &= e^{(2k+1)i\pi^2}\\ &= \cos(2k+1)\pi^2+i\sin(2k+1)\pi^2.\end{aligned}$$

Consequently, the given combination of symbols represents a set of complex numbers having the constant modulus,

$$|\pi^{\pi}| \qquad (=36.46 \text{ nearly})$$

and such that the arguments of successive numbers differ by π whole revolutions.

The given expression cannot have any real values for if integers h and k could be chosen so that

$$(2k+1)\pi^2 = h\pi,$$

π would be a root of a quadratic equation with integral coefficients.

But, by Lindemann's Theorem, π is not the root of any algebraic equation with integral coefficients.

Similar argument shows that no value of the expression is repeated for a different k.

Hence $(-\pi)^{\pi}$ has a single infinity of complex values.

Also solved by A. PELLETIER *and one incorrect solution received.*

635. *Proposed by Walter R. Warne.*

Find the maximum value of $(\csc^2\theta-\tan^2\theta)/(\cot^2\theta+\tan^2\theta-1)$.

I. *Solution by R. T. McGregor, Elk Grove, Calif.*

The expression may be written as

$$(\tan^2\theta-\tan^4\theta+1)/(\tan^4\theta-\tan^2\theta+1) = -1+2/(\tan^4\theta-\tan^2\theta+1),$$

which will be a maximum when $\tan^4\theta-\tan^2\theta+1$ is a minimum. The minimum value of this function is 3/4 (when $\tan\theta = \sqrt{2}/2$). Hence the maximum value of the given expression is $-1+8/3 = 5/3$.

II. *Solution by A. Pelletier, Montreal, Can.*

Let $m = \tan^2\theta$ and the given expression becomes

$(1/m+1-m)/(1/m+m-1)$ or $(1+m-m^2)/(1-m+m^2) = k$, say.

Then $(k+1)m^2-(k+1)m+k-1 = 0$; m being real.

$$(k+1)^2-4(k+1)(k-1) \geq 0.$$

Hence, k varies from -1 to 5/3. Therefore k, or the given expression, has 5/3 for maximum value.

Digitized by Google

Also solved by N. BAROTZ (*using calculus*).

Errors.

Second equation of problem 636, page 90 (January, 1920) should have the third term read xy instead of xy^2.

Problem 637 should conclude with AB/C *to the n-th power* instead of *multiplied by n*.

In the same issue the editor's statement numbered V in the solutions of problem 622 is incorrect and worthless.

PROBLEMS FOR SOLUTION.

646. *Proposed by A. Pelletier, Montreal, Can.*

Find the remainder of the division of 6^{592} by 11.

647. *Proposed by Walter R. Warne, State College, Pa.*

$S_1, S_2, S_3, \cdots S_p$ are the sums of p arithmetical progressions, each continued to n terms; the first terms are 1, 2, 3, $\cdots p$, respectively, and the common differences 1, 3, 5, $\cdots 2p-1$. Prove that $S_1+S_2+S_3+\cdots+S_p = np(np+1)/2$.

648. *Proposed by J. W. Lyle, Hartwell High School, Cincinnati, O.*

In the right dihedral angle formed by a floor and a wall is built a rectangular coal bin four feet high which extends three feet from the wall. What are the possible positions of a ladder eleven feet long that will touch the wall, the bin and the floor at the same time?

649. *Proposed by Walter R. Warne.*

If the inscribed circle of the triangle ABC passes through the center of the circumscribed circle, then

$$\cos A+\cos B+\cos C = \sqrt{2}.$$

650. *Proposed by Norman Anning, Orono, Me.*

Two hunters start from the same camp. A goes one mile east and then one mile N 18°E. B goes one mile N 30°E and then one mile N 54°E. Find the distance and direction of B from A.

News Items.

It pleases us to note that Norman Anning, a long time contributor to this department, has joined the faculty of the University of Maine.

R. M. Mathews, who has also contributed much to the success of this department, is now a member of the faculty of the University of Minnesota.—[*American Mathematical Monthly.*

NOTICE.

We are sorry to announce that Mr. William L. Eikenberry of the University of Kansas, for many years at the Head of our Botany Department, has been obliged to withdraw on account of the press of other duties. Mr. Worralo Whitney, who for a long period has been conducting the Zoology Department, has been given, at his request, the Department of Botany. For the Editor of the Zoology Department we have been exceedingly fortunate in securing Mr. Harold B. Shinn of the Schurz High School, Chicago.

Digitized by Google

SCIENCE QUESTIONS.

Conducted by Franklin T. Jones.

The Warner & Swasey Company, Cleveland, Ohio.

Readers are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, 10109 Wilbur Ave., Cleveland, Ohio.

Examination and Test Papers.

Please send examination papers on any subject or from any source to the Editor of this department. *He will reciprocate by sending you such collections of questions as may interest you and be at his disposal.*

Send in any tests you are trying. Others will be interested in what you are doing.

State teachers' examination papers and State examination papers for pupils are also much desired. What States have such examinations? Please inform the Editor how and where they may be obtained.

ACKNOWLEDGMENTS.

The receipt of examination papers and examination information is gratefully acknowledged from the following:

J. T. Ross, Deputy Minister of Education, Edmonton, Alberta.

H. J. Silver, Secretary-Superintendent, Protestant Board of School Commissioners, Montreal.

W. S. Carter, Chief Superintendent of Education, Fredericton, New Brunswick.

A. H. MacKay, Superintendent of Education, Halifax, Nova Scotia.

R. H. Blacklock, Registrar, Dept. of Education, Regina, Saskatchewan.

L. J. Willis, Superintendent of Education, Victoria, British Columbia.

C. M. McCann, Chief Clerk, Dept. of Education, Winnipeg, Manitoba.

P. M. Dysart, Schenley High School, Pittsburgh, Pa.

QUESTIONS AND PROBLEMS FOR SOLUTION.

337. *Proposed by A. Haven Smith, Riverside, Calif.*

An enemy tank is observed 400 yards away. It is advancing at a speed of 6 miles per hour. Assume a muzzle velocity of 259 feet per second and vacuum conditions.

(a) What will be the time of flight of the shell?

(b) How far will the tank have moved during the flight of the shell?

(c) What is the correct angle of elevation?

Proposed by the editor.

Let us hear from some of our artillery friends in answer to the question.

(d) Are the above conditions practical ones? If not, why not?

(e) What would be a statement in accordance with actual conditions?

(d) What would be the solution in case "vacuum conditions" were not assumed?

EXAMINATIONS.

Submitted by W. S. Carter, Chief Superintendent of Education, Fredericton, New Brunswick.

High School Entrance Examinations, *New Brunswick.*

Nature Study, Agriculture and Health.

Time—2 Hours.

F. A. Good.

Values.

15 1. Write some observations you have made concerning *one* of the following: (*a*) a destructive insect, (*b*) a plant disease, (*c*) troublesome bird.

20 2. Name six different species of birds that are permanent residents of New Brunswick. Which of these are of value to man, and in what way?

Digitized by Google

15 3. Name four of the earliest wild flowers found in your neighborhood. State where they are found and make a drawing of one of them.

15 4. Write a paragraph on methods employed on the farm or in the garden to rid the land of weeds. Why is this necessary? Show clearly why this same process must be repeated year after year.

or

Write a paragraph on any observation or experiment you have made concerning weeds.

20 5. Make a list in the order of their importance of the domestic animals found on the farms of New Brunswick. Discuss usefulness of first named.

15 6. Describe accurately the planting and cultivation of one farm crop.

or

Describe the planting and cultivation of one product of the garden.

15 7. What are the functions of the lungs, liver and kidney? What is the effect of alcohol on each?

20 8. What changes must the different classes of food undergo before they may be used in the human body? Why are these changes necessary?

15 9. Give theory and rules governing the practice of (*a*) bathing, (*b*) chewing food.

150

June, 1919.

Normal School Entrance Examinations, *New Brunswick.*

Nature Study.

Class I. Time—1 Hour, 30 Min.

(Questions are of equal value.)

1. Give approximate dates of the return of six migratory birds that you have observed this year. Explain as far as you can why these birds left our Province and why they returned. Argue as to whether they should be called New Brunswick or southern birds.

2. Why should bird life be studied in the public schools? Describe the English Sparrow and one less common resident bird.

3. Show how the following anticipate the winter, i. e., how they prepare for it: (*a*) a deciduous tree; (*b*) a perennial that dies to the ground each fall; (*c*) an annual.

4. What plants found in New Brunswick but not cultivated are used for food for human beings? What animal forms not reared by man are also used for same purpose? What important difference is to be noted between the food of animals and that of plants?

5. Name four weeds that persist about human dwellings in spite of efforts to exterminate them. Describe one and draw one. Explain as far as you can why it is difficult to eradicate these plants.

6. Describe two experiments or observations which you have made, one relating to germination of seed or other garden work, and the other to insect life.

July, 1919.

SOLUTIONS AND ANSWERS.

318. *Proposed by Hanor A. Webb, Nashville, Tenn.*

The atomic weight of the gas helium is 4. In discussing the use of this gas as a substitute for hydrogen in balloons, the *Scientific American* has recently correctly stated that helium was only twice as heavy as hydrogen. Explain this apparent discrepancy.

Solution by the proposer.

An atom of helium is four times as heavy as an atom of hydrogen. But hydrogen, as a gas, exists in the molecular form with its atoms in pairs, as H_2, while helium, being one of the "inert gases" without combin-

Digitized by Google

ing power, exists in the atomic form, as He_1. Thus, a given volume of He_1 is only twice as heavy as the same volume of H_2.

335. *Proposed by W. L. Malone, Tacoma, Wash.*

"If a man can jump 3 feet high on the earth, how high could he jump on the moon, where g is 1/6 as much?"

Solution by F. D. Mack, La Crosse, Wisconsin.

1. $v_1 = \sqrt{2a_1s_1}$

Because a body starting from rest with uniform acceleration, the change in velocity in a given distance is numerically equal to the square root of twice the product of the acceleration and the distance.

2. $v_2 = \sqrt{2a_2s_2}$
3. $\therefore \frac{a_1}{a_2} = \frac{s_2}{s_1}$

Because the initial velocity v_1 on the earth is the same as the initial velocity v_2 on the moon.

By substitution,

4. $\therefore 1/(1/6) = s_2/3$

The product of the means equals the product of the extremes.

5. $\therefore 1/6s_2 = 3$
6. $\therefore s_2 = 18$, the height he can jump on the moon.

Solution by W. L. Malone, Tacoma, Wash.

First on the earth:

$v_1 = \sqrt{2gs_1} = \sqrt{6g}$

Let F = the average value of the jumping effort.

$\therefore$ The force to which v_1 is due = $F - mg$, where m = the man's mass, hence

$(F - mg)t_1 = mv_1 = m\sqrt{6g}$

$\therefore F/m = \sqrt{6g}/t_1 + g$

Now F/m = the acceleration produced in m by F, when unopposed by gravity, and hence is independent of g, though given here in terms of g.

Second, on the moon:

We assume that the man makes the same effort here as before, hence, $[F - m(g/6)t = mv$

$\therefore v = (F/m - g/6)t = (\sqrt{6g})/t_1 + 5g/6)\ t$

$\therefore 2(g/6)s = (\sqrt{6g}/t_1 + 5g/6)^2t^2$

Or $s = 3(\sqrt{6g}/t_1 + 5g/6)^2t^2 = 3g(\sqrt{6}/t_1 + 5\sqrt{g}/6)^2t^2$

(But little consideration will show that $t < t_1$.)

Now if d is the distance through which F acts, it is the same in both cases; so also F, hence the work done is the same in both; the equation of energy is therefore,

$E = mgd + 3mg = m(g/6)d + (1/2)mg(\sqrt{6}/t_1 + 5\sqrt{g}/6)^2t$

$\therefore 5d/6 + 3 = s/6$ or $s = 18 + 5d$.

Hence s is a function of d.

Hence also two men who can jump to the same height on the earth, may not be able to jump to the same height on the moon and vice versa.

ARTICLES IN CURRENT PERIODICALS.

American Journal of Botany, for December; *Brooklyn Botanic Garden; $5.00 per year, 60 cents a copy:* "Influence of Sugars on the Growth of Albino Plants," L. Knudson and E. W. Lindstrom; "Variations in Pleurage Curvicolla (Wint.) Kuntze," J. L. Weimer; "Inheritance of Sex in Mercurialis Annua," Cecil Yampolsky; "Germination and Further Development of the Embryo of Zea Mays Separated of the Ermndosperm," Demetrius Ion Andronescu.

American Mathematical Monthly, for December; *Lancaster, Pa.: $4.00 per year, 50 cents a copy:* "Mathematics and Statistics with an Elementary Account of the Correlation Coefficient and the Correlation Ratio,"

Digitized by Google

E. V. Huntington; "Meeting of the Minnesota Section"; "The Work of the National Committee on Mathematical Requirements"; Questions and Discussions: "Dup'n's Theorem," D. C. Kazarinoff; "A Property of Homogeneous Functions," J. E. Trevor; "Graphical Constructions for Imaginary Intersections of Line and Conic," R. M. Mathews.

Journal of Geography, for January; *Broadway at 156th Street, New York; $1.00 per year, 15 cents a copy:* "New Boundaries of Austria, Capital Cities," F. Hamburg; "Finding Farms for Returned Soldiers," Ona I. Nolan; "Black Diagrams," A. K. Lobeck.

Literary Digest, for February 7; *New York City; $4.00 per year, 10 cents a copy:* "Alien and Sedition Bills of 1920"; "Socialism on Trial at Albany"; "The Kansas Strike Cure"; "Germany's Mysterious Army"; "Turkey to Remain in Europe"; "The Best Artificial Limbs Yet."

National Geographic Magazine, Washington, D. C.; $3.00 per year, 35 cents a copy: "The Removal of the North Sea Mine Barrage" (28 illustrations); Noel Davis; "Skiing Over the New Hampshire Hills," (37 illustrations), Fred H. Harris; "Winter Rambles in Thoreau's Country" (15 illustrations), Herbert W. Gleason; "Where the World Gets Its Oil" (21 illustrations), George Otis Smith.

Nature-Study Review, for December; *Ithaca, N. Y.; $1.00 per year, 15 cents a copy:* "Cooty, a Pet Coati," Alfred E. Emerson, Jr.; "Night Fairies' Rendezvous," E. Eugene Barker; "Chamois at Home," Peter A Mattli; "Pocket Gopher," Mae Creswell; "Virginia Deer," George H. Russell; "Our Pet Chipmunk Uncas," Jay Traver; "Notes on the Blacksnake," Helen H. Humphrey; "The Grizzly Bear," Lois I. Webster; "Raccoon," George B. Happ; "Burrowing Raccoons," L. B. Cushman.

Photo-Era, for January; *Boston, Mass.; $2.00 per year, 20 cents a copy:* "Technical Knowledge Behind the Photo-Counter," Photographic Dealer; "Architectural Traditions for the Photographer," Edward Lee Harrison; "Combination-Printing," The British Journal; "What Photography Has Done For Me," Michael Gross; "Winter-Landscapes," William S. Davis; "The Airplane in Pictures," Latimer J. Wilson; "Price Cooperation," Edgar M. Atkins; "Equipment for Color-Photography," Robert M. Fanstone; "Photographing Children," Wilson Todd; "A Photographic Gambol," L. B. Flint; "At-Home Lantern-Screens," Lanternist.

Physical Review, for December; *Ithaca, N. Y., $7.00 per year, 75 cents a copy:* "The Optical Constants of Liquid Alloys," C. V. Kent; "On the Maintenance of Vibrations of Wires by Electrical Heating," N. C. Krishmaiyar; "On the Diffraction Theory of Microscopic Vision," Phanindra Nath Ghosh; "Resonance and Ionization Potentials for Electrons in the Monatomic Gases Argon, Neon, and Helium," H. C. Rentschler; "On the X-Ray Absorption Frequencies Characteristic of the Chemical Elements," William Duane and Kang-Fuh-Hu; "On the X-Ray Absorption Frequencies Characteristic of the Chemical Elements," William Duane and Takeo Shimizu; "The Relation between the Intensity of General X-Radiation and the Atomic Number of the Anticathode," William Duane and Takeo Shimizu.

Popular Astronomy, for February; *Northfield, Minn.; $4.00 per year:* "Various Suggestions Relating to Stellar Evolution, Planetary Genesis, and Hyperbolic Comets" (with Plate III), William H. Pickering; "First Study of Heavenly Bodies, Lesson II," Mary E. Byrd; "Celestial Photography for Amateurs by an Amateur (with Plates IV and V), Dean B. McLaughlin; "Sirius at Sea," Charles Nevers Holmes; "The French Republican Calendar and Some Others," Roscoe Lamont; "The Decimal System for Time and Arc for Use in Navigation," Charles E. Manierre; "Report on Mars, No. 22" (with Plate VI), William H. Pickering; "Yerkes Observatory 1919," Edwin B. Frost.

School Review, for February; *University of Chicago Press $1.50. per year, 20 cents a copy:* "The Ben Blewett Junior High School of St. Louis—Part II," R. L. Lyman; "A Study of Applied Music," Frank A. Scott; "Wherewith Shall We Be Clothed?" Anonymous; "Compulsory Education in the Southern Colonies," Marcus W. Jernegan; "Vocational Guidance and the Theory of Probability," Harry D. Kitson.

Digitized by Google

BOOKS RECEIVED.

A Field and Laboratory Guide in Physical Nature-Study, by Elliot R. Downing, University of Chicago. 109 pages. 16.5×21.5 cm. Paper. 1920. $1.10. The University of Chicago Press.

Laboratory Exercises in Chemistry, by Charles E. Dull, South Side High School, Newark, N. J. 224 pages. 19.5×24.5 cm. Paper. 1919. Henry Holt & Company, New York City.

General Mathematics, by Raleigh Scharling, Lincoln School of Teachers College, Columbia University, and William D. Reeve, University High School, University of Minnesota. Pages xvi+488. 13.5×19 cm. Cloth. 1919. $1.48. Ginn & Company, Chicago.

The Geography of the Ozark Highland of Missouri, by Carl O. Sauer. Pages xviii+245+51 half-tones. 16.5×24 cm. Cloth. 1919. $3.15. The University of Chicago Press.

Plane Geometry, by Mabel Sykes, Bowen High School, Chicago, and Clarence E. Comstock, Bradley Polytechnic Institute, Peoria, Ill. Pages xii+322. 13.5×20 cm. Cloth. 1919. Rand McNally & Company, Chicago.

Elements of Vector Algebra, by L. Silberstein, University of Rome. 42 pages. 14×22 cm. Cloth. 1919. $1.60. Longmans, Green & Company, New York City.

Junior Science, by President John C. Hessler, The James Millikin University. Pages xii+243. 14.5×19.5. Cloth. 1920. Benj. H. Sanborn & Company, Chicago.

Pamphlets Received.

Bulletin No. 72, Bureau of Education, an Abstract of the Report on the Public School System of Memphis, Tenn.

Bulletin No. 44, Bureau of Education, Modern Education in China.

Bulletin No. 51, Bureau of Education, The Application of Commercial Advertising Methods to University Extension.

Manual for Conservation of Vision Classes, National Committee, 130 East 22nd St., New York City.

Bureau of Educational Research, Bulletin No. 2, The University of Illinois.

Teachers' Salaries and Salary Schedules in the United States, The National Education Association, by E. S. Evenden, Washington, D. C.

ALBERTS TEACHERS' AGENCY.

For the past few years the Albert Teachers' Agency, 25 E. Jackson Boulevard, Chicago, has published a pamphlet for gratuitous distribution to teachers, entitled "Teaching as a Business." The new edition of this pamphlet has very interesting chapters on "Forecast," "Scarcity of Teachers," "Letter of Application," and other timely topics. More than four thousand of these booklets were called for last year by Professors of Education in Colleges and Normal Schools who used them in their class rooms. The discussion of the salary question is forceful and vigorous.

EDUCATION

40th year Sept. 1919. $3 a year. Sample 20c.
120 Boylston St., Boston, Mass.
"AS NECESSARY TO A TEACHER AS A MEDICAL JOURNAL TO A PHYSICIAN"

Digitized by Google

BOOK REVIEWS.

Number by Development, Vol. II, Intermediate Grades, by John C. Gray, A. M., Superintendent of Schools, Chicopee, Mass. Pages xxii+486 +xi. 13×19 cm. 1919. J. B. Lippincott, Philadelphia.

The purpose of this book is to furnish a working outline in detail of class work in common fractions in accordance with development ideals and suggestions in denominate numbers. The development theory and its use and the principles in teaching practice are explained fully. In addition to the details of subject matter, the teacher is shown the sequence of teaching steps, the form of objective work and methods of drawing pupils' attention to the line of development thought and holding it there for a properly sustained consideration of the unit of truth involved.

H. E. C.

Div-a-let, Second Edition, by W. H. Vail, A. M., M. D. Pages 70. 12×20 cm. Paper covers. The Revell Company Press.

This book contains 322 examples in division in which letters are used in the place of digits. The problem is to obtain the word or series of letters hidden in the example. In the words of the author, it is "A pastime or mental diversion, mostly intended for those who are fond of such things." The exercise of considerable ingenuity is required to find the hidden word, and some knowledge of number combinations may be gained. Copies, price 50 cents each, may be obtained of the author. Address 141 Second Avenue, Newark, N. J. H. E. C.

Correlated Mathematics for Junior Colleges, by Ernst R. Breslich, Head of the Department of Mathematics in the University High School, The University of Chicago. Pages xiii+301. 14×20 cm. $1.25. 1919. The University of Chicago Press.

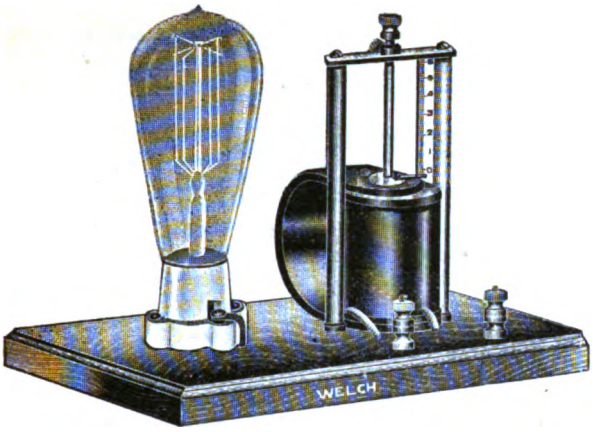
The work usually covered in separate course in college algebra and analytic geometry are combined in this book. As in the other books in this series, mathematical topics which are naturally related to each other are closely associated. The author has done this with such a clear perception of mathematical facts and skill in uniting them that the student may gain a ready knowledge of principles and processes and apply them intelligently in any problem without stopping to consider whether he shall use algebra or geometry. The definitions, explanations and illustrations are sufficiently precise and exact, but are put in everyday language which can be readily grasped by the student. H. E. C.

A Short Course in College Mathematics, by Robert E. Moritz, Ph. D., Professor of Mathematics in the University of Washington. Pages ix+236. 13×19 cm. 1919. The Macmillan Company, New York.

For the essentials of algebra and trigonometry and a working knowledge of graphs and coördinate methods, this book offers a most satisfactory choice of subject matter and applied problems. While the material is greatly condensed it includes all the principles essential for analytic geometry and calculus, or engineering and other fields of applied science.

The problems are closely correlated with the descriptive matter, and not only emphasize the fundamental principles but also give the student the ability to use his knowledge in doing things in a practical way. The use of this book will certainly give students firm grounding for future work and shorten the time of preparation. H. E. C.

Digitized by Google



QUALITY WELCH SERVICE

2601-CHOKE COIL This is a newly designed instrument which illustrates one of the most fundamental pinciples of electricity. It consists of a coil of many turns of wire connected in series with an incandescent lamp. The coil is wound around an iron core and a U-shaped armature of iron completes the magnetic circuit. The iron core may be withdrawn from the coil and thus the magnetic circuit may be broken and the air gap lengthened and shortened at will. When this instrument is connected to alternating current the current is varied by withdrawing or inserting the core in the coil. This shows most effectively that the "equivalent resistance" of the coil depends on the arrangement of the magnetic circuit outside—there is no change of the length or size of wire as in an ordinary rheostat. Ohms law does not fully apply here and this apparatus shows this definitely, and demonstrates the existence of the quantity known as "impedance."

As a demonstration piece it may be used before a class and show this principle to all at the same time, since when the core is withdrawn or inserted the lamp grows alternately bright and dim.

As a student piece it presents a very valuable test for the student to make measurements on, and the current and voltage in this coil when the core is in different positions may be measured. This will enable the student to calculate the apparent resistance and he will find that resistance is not constant as *Ohms law only* would show. The instrument is provided with a scale on one side so that the student may know exactly the length of air gap existing in the core, and some very definite ideas may be gained as to choking effect of an alternating current.

When direct current is used this instrument does not show this effect and when comparing the use on direct current to the use of it with alternating current it shows very forcibly this quantity of "impedance." By far the greater part of the commercial work is with alternating current and an increasing number of texts are including the teaching of these principles. This instrument will fill this very important need. The entire instrument is about 20 cms. high mounted on a mahogany finished base about 15x20cms. Complete coil mounted as shown and with incandescent light. Very handsomely finished and durably made.

A mark of quality

QUALITY WELCH SERVICE

from a house of service

W. M. Welch Scientific Company

Manufacturers, Importers and Exporters of Scientific Apparatus

1516 Orleans Street Chicago, Ill. U. S. A.

Digitized by Google

Vocational Agricultural Education, by Home Projects, by Rufus W. Stinson, State Supervisor of Vocational Education in Massachusetts. Pages xxxviii+468. 13×18 cm. 307 figures. $2.50. 1919. The Macmillan Company.

The book is written for students of vocational agricultural methods used in schools and project teaching. It is for the young teacher of vocational agriculture and is packed full of argument, data, and illustrative examples pertaining to the work. It is meant to be and is a source book in this subject.

The illustrations are very numerous and are all illustrative of actual project work. They may form a good course of instruction in themselves, for they are protographs and well chosen to tell a progressive story. We heartily recommend those interested in agricultural education to investigate this book. W. W.

Elementary Biology, An Introduction to the Science of Life, by Benjamin C. Gruenberg, Julia Richman High School, New York. Pages x+528, 262 illustrations. 13x18 cm. 1919. Ginn & Company.

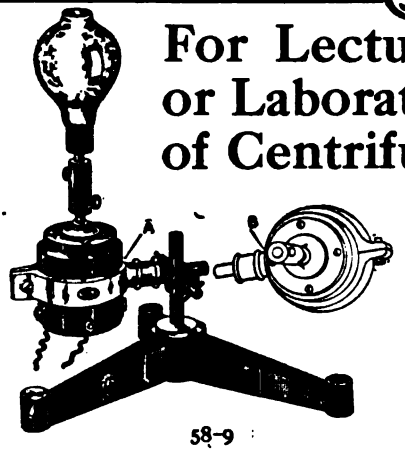
As a rule, in the smaller schools, where one year is given to biology, the work is divided between botany and zoology. Real courses in biology are seldom given. The practice of giving botany and zoology as half-year courses is bad for the reason that the subjects are large and teachers seldom have the courage to vigorously confine their work to just what can be well done. There is always the tendency to cover too much of the field in the short time available with the result that the work is superficial and hurried. It is no wonder that botany and zoology have been losing ground.

One reason for bad results in biological courses has been due to the textbooks. Uusally books more suitable for a year's work in each subject are used. There are very few books suitable for half-year courses and still fewer books in which animals and plants are combined in a single course, as biology. In *Gruenberg's Elementary Biology* teachers have an opportunity to use a worth-while book. It combines animals and plants in one course under biological topics. The subjects chosen are most important and the treatment clean-cut. The text is abundantly illustrated with figures that help tell the story. We unhesitatingly recommend the book to teachers of half-year courses in botany and zoology as giving an opportunity for doing more vital, interesting and better work.

Before closing this review, however, attention should be called to certain features of the book. It is written by a New York teacher and therefore is made to suit the peculiar conditions prevailing in that state. Human physiology and hygiene are included. Most schools nowadays include physiology in the general science course and give it in the first year of the high school. We feel also that the book is too crowded and the presentation rather too "meaty" for students of the ninth and tenth grades. However, this is not so bad a fault as being too wordy and discursive, a fault of many texts whose authors, in trying to make the thought clear to young students, simply confuse the thought with too much explanation. The wise teacher will avoid the faults of the inclusion of physiology which has already been given and the overcrowding by omitting what cannot be well done in the time at his disposal. Good textbooks are too scarce to reject because of faults so easily remedied. W. W.

Plant Production; Part I, Agronomy; Part II, Horticulture; by Ransom A. Moore, University of Wisconsin, and Charles P. Halligan, Michigan Agricultural College. Pages 428 with 210 illustrations. 12x16 cm. 1919. American Book Company, Chicago.

Digitized by Google



For Lecture Demonstration, or Laboratory Application, of Centrifugal Force . . . . .

58-9

The Waverley-Electric Specifications

Support—Standard Tripod.
Yoke—Cast Aluminum.
Housing—Enameled Iron.
Motor—6,000 R. P. M.
Mica Insulation. Self-Adjusting Brushes.
Ball-Bearing Shaft.
Current—D. C., A. C., or Dry Cells.
Chuck—Universal.

You Need This Waverley Electric—
A Whirling Machine and Centrifuge Combined.

As a whirling machine the Waverley-Electric takes a Centrifugal Globe (as illustrated), or Double Hoops, Centrifugal Balls, and other accessories.

A Centrifuge Head converts the Waverley-Electric into a powerful centrifuge that may be used with efficacy for the analysis of milk, urine, blood, or other liquids.

The specially designed, ball-bearing motor is mounted and balanced to operate in vertical or horizontal position. Consequently its general utility includes the rotation of Savart's Wheels, Siren Discs, Newton's Color Discs and the like.

58-9 The Waverley-Electric, including Support, Yoke, Motor and Chuck.....$19.00
58-9a Waverley Centrifuge Head, four-arm.. 3.75

Cambridge Botanical Supply Company

LABORATORY EQUIPMENT—ALL SCIENCES

1-9 Lexington Street **1884-1920** **Waverley, Mass.**

This textbook is written for use in schools providing for vocational instruction in agriculture. The authors have aimed to make the book "useful, practical and of immediate application."

The style of the book is simple, clear and direct. The subject matter appears to be well chosen for the purpose of the book. The illustrations are good and help the text tell the story. As the title suggests, Part I deals with the grain, hay and other crops of the farm, while Part II takes up the garden and orchard, including the home and its surroundings. The treatment of each topic is very comprehensive and practical. We think the authors have been successful in this undertaking and that the book is worthy of careful consideration for the grade and kind of school work for which it is intended. W. W.

An Introductory Course in Quantitative Chemical Analysis, with Explanatory Notes, Stoichiometrical Problems and Questions, by George McPhail Smith, Associate Professor of Chemistry in the University of Illinois. Pages x+206. 17x15.5x2 cm. Cloth. 1919. The MacMillan Company, N. Y.

This new manual of quantitative analysis is intended for use by beginners, who have presumably had a year of general chemistry and a course in qualitative analysis.

Part I deals with the general principles and with the special manipulations used in quantitative analysis. It is apparently intended both for a preliminary survey of methods and for frequent specific reference later on.

Part II treats of gravimetric analysis and Part III of volumetric analysis.

Part IV has eight pages devoted to stoichiometry.

Part V consists of questions.

An appendix deals with preparation of reagents, of analytical samples, and of apparatus. A logarithm table is also furnished.

Digitized by Google

The analyses selected for practice seem to be very well chosen. They cover a sufficient range so that all students, no matter what line of work they may ultimately specialize in, will find themselves well grounded in the fundamental methods of analysis.

The explanations of the reasons for the methods employed are excellent, see, for example, the notes, pages 89-96, in regard to the electrolytic determination of copper.

With this manual the instructor should be free to devote most of his time to the development of fundamental principles of the subject as the detailed instructions are so clear and so complete that the student of college caliber should find little difficulty in following them. F. B. W.

College Textbook of Chemistry, by W. A. Noyes, Director of the Chemical Laboratory of the University of Illinois. 1st Edition. Pages viii+370. 13.5x19x2 cm. Cross-section drawings. Cloth. 1919. Henry Holt & Company.

The first impression one receives on seeing this little book from the pen of the New President of the American Chemical Society is that there must be a second volume, so much smaller is it than the usual college text in general chemistry.

A glance at the measurements above or at the number of pages will at once apprise the reader of this review that the book is not much over half the usual size.

A careful study of the text, however, will show that it is full of meat, and that the author, with the courage of his convictions, has dared to omit the greatest lot of interesting things in order that the student who uses the text may have a real chance, not only to learn most of the subject matter included, but to get an adequate sense of things chemical as he studies the book.

To this end the order of subjects has been artfully chosen and the succession of topics is such as to lead to progressive growth in power to use and apply what has gone before. That the interrelation of topics may not be overlooked much cross referencing has been provided. This is not overdone but occurs frequently enough to give the earnest student every chance to link up the present topic with related antecedents.

The early introduction of comparatively recent chemical theory is noteworthy and in line with the best modern thought. Why should we follow the calf paths of the past instead of making straight the way? Such a short circuiting comes from the early teaching of the ionic theory (page 65) and the fairly consistent use of it thereafter. Valence is admirably presented at a comparatively early point (page 100). The hypothesis of Avogadro and its necessary consequences are well presented in the twelfth chapter.

Nor is the practical overlooked by the author in his enthusiasm for teaching the underlying theories of the subject. Every now and then we find some up-to-date, practical application of chemistry referred to and explained.

A somewhat out of the ordinary feature for a college text is the summary and set of questions at the end of each chapter. This is good pedagogy, however, and has been found valuable in high school texts.

In more ways than one the new text resembles some of the better high school texts. It frankly treats the student as a beginner, and recognizing that all beginnings are hard it tries to help him over some of the difficulties, without, however, coddling him too much. Many a college text has failed to recognize the need for this type of approach, with the result that only the brilliant student or the tireless plugger got much out of it.

Digitized by Google

New Botany Texts

Eikenberry's Problems in Botany

The materials are organized with reference to the *life* of the plant rather than to its *structure*. The problem method of presentation is followed. Illustrated.

Densmore's General Botany

For universities and colleges. Plants are presented as living, active organisms, comparable to animals and with similar general physiological life functions. Amply illustrated.

Densmore's Laboratory and Field Exercises for General Botany

Prepared especially for use with Densmore's "General Botany," these exercises can readily be adapted for use with any standard text.—*Nearly Ready.*

Caldwell and Eikenberry's Laboratory Manual for Work in General Science (Revised)

A revision incorporating changes which are the result of constant trial, elimination, and addition in many first-year science classes.

GINN & COMPANY Boston New York Chicago London Atlanta Dallas Columbus San Francisco

College teachers of general chemistry will do well to consider this new text carefully, and many a high school teacher can improve his teaching if he will study its methods and its content.

It will be found especially helpful in applying modern concepts, like that of the electron, for example, to the consideration of the facts of chemistry. The author has shown much originality in the creation of this text and has blazed a trail that may well be followed, and perhaps smoothed up, by others.

Exercises in Chemistry, by William A. Noyes, Director of the Chemical Laboratory, and B. Smith Hopkins, Asst. Professor of Inorganic Chemistry, in the University of Illinois. 2nd edition. Pages vi+131. 12.5×19×1 cm. Cross-section drawings. Paper. 1917-1919. N. Y. Henry Holt & Company.

This revised edition of *Exercises in Chemistry* follows in part the order of treatment of the *College Textbook of Chemistry* reviewed above.

Its aims are similar, namely, to bring about thoughtful consideration of the facts of chemistry in the light of modern theories. The many leading questions interspersed with the directions help in this regard, as do the several hundred exercises for the classroom provided in the back of the volume. The directions are clear and concise, but not too brief for students of college age. The object or purpose of each experiment is usually indicated only by a brief title. In this respect, perhaps too telegraphic a style is employed, though in many cases the brief title sufficiently announces the nature of the experiment. In the latter portions of the book, as also in the textbook just reviewed, considerable space is devoted to the chemistry upon which schemes of qualitative analysis are based. This material affords excellent practice in applying the chemical knowledge that the student has gained, and even though he may not be intending to follow up the subject he can well afford to give the time to it. As the child is father to the man, so this little manual may have been the progenitor of the excellent college text which it preceded. F. B. W.

Digitized by Google

DIRECTORY OF SCIENCE AND MATHEMATICS SOCIETIES.

Under this heading are published in the March, June, and October issues of this Journal the names and officers of such societies as furnish us this information. We ask members to keep us informed as to any change in the officiary of their society. This is extremely valuable information to all progressive teachers. Is your Society listed here? Names are dropped when they become one year old.

AMERICAN GEOGRAPHICAL SOCIETY OF NEW YORK.

President, John Greenough; *Vice-Presidents*, Paul Tuckerman and James B. Ford; *Foreign Corresponding Secretary*, William Libbey; *Domestic Corresponding Secretary*, Archibald D. Russell; *Recording Secretary*, Hamilton Fish Kean; *Treasurer*, Henry Parish; *Director and Editor*, Isaiah Bowman, Ph.D.—1220.

AMERICAN PHYSICAL SOCIETY.

President, J. S. Ames, Johns Hopkins University, Baltimore, Md.; *Vice-President*, Theodore Lyman, Harvard University, Cambridge, Mass.; *Secretary*, D. C. Miller, Case School of Applied Science, Cleveland, Ohio; *Treasurer*, G. B. Pegram, Columbia University, New York City; *Editor*, F. Bedell, Cornell University, Ithaca, N. Y.; *Local Secretary for the Pacific Coast*, E. P. Lewis, University of California, Berkeley, Cal. *The Council of the Society consists of the President, Vice-President, Secretary, Treasurer, Managing Editor, all living Past Presidents and eight elected members as follows: Past Presidents:* A. A. Michelson, A. G. Webster, Carl Barus, E. L. Nichols, Henry Crew, W. F. Magie, Ernest Merritt, R. A. Millikan, H. A. Bumstead; *Elected Members:* Max Mason, G. O. Squier, H. A. Wilson, A. L. Day, G. F. Hull, G. K. Burgess, J. C. McLennan, F. B. Jewett; *Editor*, Frederick Bedell, Ithaca, N. Y.—220.

AMERICAN PHYSIOLOGICAL SOCIETY.

President, Prof. Frederick S. Lee, Columbia University, New York; *Secretary*, Prof. Charles W. Greene, University of Missouri, Columbia, Mo.; Next annual meeting place, Johns Hopkins Medical School—419.

AMERICAN SOCIETY OF NATURALISTS.

President, Dr. Jacques Loeb, Rockefeller Institute for Medical Research, New York City; *Vice-President*, Prof. Bradley M. Davis, University of Michigan, Ann Arbor; *Secretary*, Prof. A. Franklin Shull, University of Michigan, Ann Arbor; *Treasurer*, Dr. J. Arthur Harris, Carnegie Institution for Experimental Evolution, Cold Spring Harbor, Long Island, N. Y.—220.

AMERICAN SOCIETY OF ZOOLOGISTS.

President, Gilman A. Drew, Marine Biological Laboratory, Woods Hole, Mass.; *Vice-President*, Caswell Grave, Washington University, St. Louis, Mo.; *Secretary-Treasurer*, W. C. Allee, Lake Forest College, Lake Forest, Ill.—220.

ASSOCIATION OF AMERICAN GEOGRAPHERS.

President, Charles R. Dryer; *First Vice-President*, Dr. Herbert E. Gregory; *Second Vice-President*, Dr. Isaiah Bowman; *Secretary*, Dr. Oliver L. Fassig; *Treasurer*, Francois E. Matthes.—1219.

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS.

President, Wilmon Newell, Gainesville, Fla.; *First Vice-President*, H. A. Gossard, Wooster, Ohio; *Second Vice-President*, E. M. Ehrhorn, Honolulu, H. T.; *Third Vice-President*, J. G. Sanders, Harrisburg, Pa.; *Fourth Vice-President*, F. B. Paddock, Ames, Iowa; *Secretary*, S. F. Burgess, Melrose Highlands, Mass.; *Editor*, E. Porter Felt, Nassau, Rens. Co., N. Y.—220.

ASSOCIATION OF TEACHERS OF MATHEMATICS IN THE MIDDLE STATES AND MARYLAND.

President, W. E. Breckenridge, Stuyvesant High School, New York City; *Vice-President*, Louisa M. Webster, Hunter College, New York City; *Secretary*, C. B. Walsh, Friends' Central School, Philadelphia, Pa.; *Treasurer*, Clarence P. Scobori, Polytechnic Prep. School, Brooklyn, N. Y.; *The Council*, William Betz, Rochester, N. Y.—220.

CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

(*Annual Meeting*, November 25, 26, 27, *at Englewood High School, Chicago.*)

President, J. A. Foberg, Crane Technical High School, Chicago; *Vice-President*, Frederick R. Gorton, State Normal College, Ypsilanti, Mich; *Treasurer*, Lewis L. Hall, Morgans Park High School, Chicago; *Corre-*

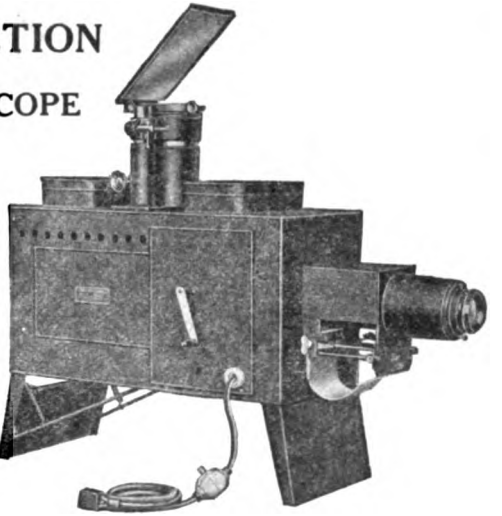
Digitized by Google

VISUAL INSTRUCTION
WITH
SPENCER DELINEASCOPE MODEL 3

is made perfect because it is an IDEAL STEREOPTICON for both lantern slides and opaque objects, such as pictures, post-cards, reading matter and objects of all kinds dead and alive.

IDEAL, because it embodies basic ideas (patented) possessed by no other. Example: Mechanical means of handling the slides, which does away with the antiquated lantern-slide holder and at the same time gives a "dissolving effect" on the screen unattained with other outfits except by using two stereopticons, one above the other.

One Spencer Delineascope does it.



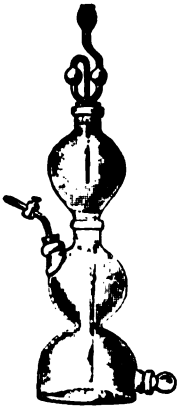
Spencers Delineascope Model 3 for both lantern slides and opaque objects. 1,000 Watt Mazda bulb illuminant. **Price, $185.00**

SPENCER BUFFALO U.S.A.

SPENCER LENS COMPANY
Buffalo, New York

Manufacturers of **Microscopes, Microtomes, Delineascopes, Optical Glass, Scientific Apparatus, Etc.**

SPENCER BUFFALO U.S.A.



No. 2402

We Carry a Complete Stock of

Chemicals & Apparatus

for the

Physical

Agricultural

Chemical

Biological

Laboratory

We Excel in Equipping High School Laboratories.
Let Us Quote Prices on Your Next List of Requirements.

THE KAUFFMAN-LATTIMER CO.

41 East Chestnut Street
Columbus, Ohio

Digitized by Google

sponding Secretary, Ally L. Marlatt, University of Wisconsin, Madison; *Assistant Treasurer*, E. S. Tillman, High School, Hammond, Indiana; the *Recording Secretary*, Harry O. Gillet, the University of Chicago, was elected last year for a two-year term. *Section Officers for 1920:*

Biology—Chairman, Grace J. Baird, Bowen High School, Chicago; *V.-Chairman*, C. P. Shideler, Joliet Twp. High School, Joliet, Ill.; *Secretary*, Elizabeth Foss, North High School, Minneapolis, Minn.; *Chemistry—Chairman*, B. J. Rivett, Northwestern High School, Detroit, Mich.; *V.-Chairman*, George Sype, Austin High School, Chicago; *Secretary*, K. J. Stouffer, Wayland Academy, Beaver Dam, Wis.; *General Science—Chairman*, G. A. Bowden, University School, Cincinnati, Ohio; *V.-Chairman*, George Mounce, LaSalle-Peru Twp. High School, LaSalle, Ill.; *Secretary*, Ruth C. Russell, Lake View School High, Chicago; *Geography—Chairman*, Wellington D. Jones, The University of Chicago, Chicago; *V.-Chairman*, R. R. Robinson, Joliet Twp. High School, Joliet, Ill.; *Secretary*, Anne B. Royeston, Hyde Park High School, Chicago; *Home Economics—Chairman*, Harriet Glendon, Lewis Institute, Chicago; *V.-Chairman*, Treva E. Kauffman, Ohio State University, Columbus, Ohio; *Secretary*, Maude M. Firth, Supervisor Home Econ., Davenport, Ia.; *Mathematics—Chairman*, M. J. Newell, High School, Evanston, Ill.; *V.-Chairman*, W. E. Beck, High School, Iowa City, Iowa; *Secretary*, Elsie G. Parker, Oak Park High School, Oak Park, Ill.; *Physics—Chairman*, H. Clyde Krenerick, North Div. High School, Milwaukee, Wis.; *V.-Chairman*, C. F. Phipps, State Normal School, DeKalb, Ill.; *Secretary*, Glenn W. Warner, Englewood High School, Chicago.—1119.

CHEMISTRY TEACHERS' CLUB OF NEW YORK CITY.

President, Alton I. Lockhart, Horace Mann School, New York City; *Vice-President*, J. Ellis Stannard, Boy's High School, Brooklyn, N. Y.; *Secretary*, Floyd L. Darrow, Polytechnic Preparatory Country Day School, Brooklyn, N. Y.; *Treasurer*, J. Hood Branson, Evander Childs High School, Bronx, N. Y.

ECOLOGICAL SOCIETY OF AMERICA.

President, Barrington Moore, American Museum of Natural History, New York City; *Secretary*, Dr. A. O. Weese, University of New Mexico, Albuquerque, N. M.—220

GENERAL SCIENCE CLUB OF NEW ENGLAND.

President, Walter G. Whitman, Normal School, Salem, Mass.; *Vice-President*, Richard T. Lunt, English High, Boston, Mass.; *Secretary*, Sumner Marvel, High School, New Bedford, Mass.; *Treasurer*, Charles Stone, English High, Boston, Mass.—1219.

GEOLOGICAL SOCIETY OF AMERICA.

President, John C. Merriam, University of California, Berkeley, Cal.; *First Vice-President*, R. A. F. Penrose, Jr., 460 Bullitt Bldg., Philadelphia, Pa.; *Second Vice-President*, Herbert E. Gregory, Yale University, New Haven, Conn.; *Third Vice-President*, Robert T. Jackson, Peterborough, N. H.; *Secretary*, Edmund Otis Hovey, American Museum of Natural History, New York City; *Treasurer*, Edward B. Mathews, Johns Hopkins University, Baltimore, Md.; *Editor*, Joseph Stanley-Brown, 26 Exchange Place, New York City.—1218.

ILLINOIS ACADEMY OF SCIENCE.

President, Henry B. Ward, University of Illinois; *Vice-President*, Geo. D. Fuller. University of Chicago; *Secretary*, J. L. Pricer, State Normal University, Normal; *Treasurer*, W. G. Waterman, Northwestern University.—319.

IOWA ACADEMY OF SCIENCE.

President, S. W. Beyer, Iowa State College, Ames; *First Vice-President*, T. C. Stephens, Morningside College, Sioux City; *Second Vice-President*, R. Monroe McKenzie, Parsons College, Fairfield; *Secretary*, James H. Lees, Iowa Geological Survey, Des Moines; *Treasurer*, A. O. Thomas, State University, Iowa City.—318.

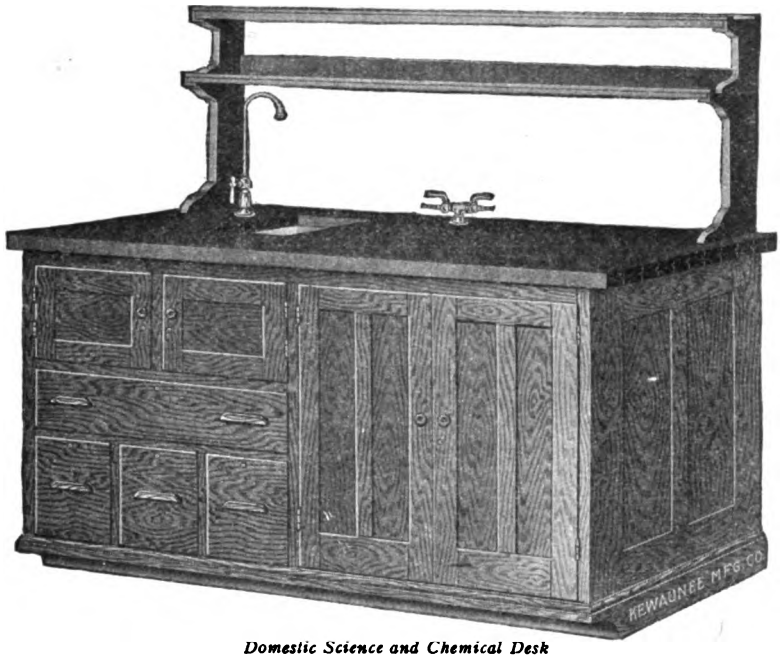
INTERNATIONAL METALLURGICAL AND CHEMICAL SOCIETY.

President, Dr. Henri Bonaparte; *Vice-President*, Carl Valdemar; *Secretary* and *Editor*, Roy Franklin Heath, c-o Billings Polytechnic Institute, Billings, Montana.—120.

IOWA ASSOCIATION OF MATHEMATICS TEACHERS.

President, W. J. Rusk, Grinnell College, Grinnell, Iowa; *Vice-President*,

Digitized by Google



Domestic Science and Chemical Desk

A Kewaunee Wall Form Foods Chemistry Desk

For Analytical work in Foods Chemistry in the Home Economics department. The well proportioned drawer and cupboard spaces, heavy "Kewaunee" top with convenient sink, cold and hot water and gas supply and the bottle shelves for chemical reagents, provide a compact work table, for either demonstrating or experimenting. Has regular "Kewounee" toe space and is designed to be set against a wall. Plumbing is all furnished to the floor line and the water and gas fittings are nickleplated brass. Three or four students together may experiment at one desk conveniently. Two or three of these desks will usually handle all the experimenting done in this direction, but in the large Domestic Science laboratories where a greater number of students work at one time, as many desks are ordered as are necessary to accommodate them and the desks then are made in a continuous wall-form type, with one top to cover the whole line of desks.

Kewaunee Mfg. Co.

LABORATORY FURNITURE EXPERTS

KEWAUNEE, WIS.

New York Office, 70 Fifth Avenue.
Chicago Office, 20 East Jackson Blvd.

BRANCH OFFICES:

Columbus
Atlanta, New Orleans, Little Rock
Dallas, El Paso
Kansas City, Minneapolis, Denver
Spokane, San Francisco

Digitized by Google

O. F. Nixon, Principal of High School, Fairfield, Iowa; *Secretary-Treasurer*, Ira S. Condit, Iowa State Teachers College, Cedar Falls, Iowa.—120.

IOWA SECTION OF THE MATHEMATICAL ASSOCIATION OF AMERICA.

President, Ira S. Condit, Iowa State Teachers College, Cedar Falls, Iowa; *Secretary*, Le Roy Coffin, Coe College, Cedar Rapids, Iowa.—120.

KANSAS ASSOCIATION OF MATHEMATICS TEACHERS.

President, J. A. G. Shirk, Pittsburg, Kansas, one year; *Vice-President*, Emma Hyde, Emporia, Kansas, one year; *Secretary-Treasurer*, Edna E. Austin, No. 6 The Devon, Topeka, Kansas, three years.—1119.

MATHEMATICAL ASSOCIATION OF AMERICA.

President, David Eugene Smith, Teachers College, Columbia University; *Vice-Presidents*, Helen A. Merrill, Wellesley College, Wellesley, Mass., and E. J. Wilczynski, University of Chicago, Chicago, Ill.; *Secretary-Treasurer*, W. D. Cairns, Oberlin College, 27 King Street, Oberlin, Ohio.—120.

NATIONAL EDUCATION ASSOCIATION.

President, Josephine Corliss Preston, Olympia, Wash.; *Secretary*, J. W. Crabtree, Washington, D. C.; *Treasurer*, A. J. Matthews, Tempe, Ariz.; *Department of Secondary Education: President*, W. W. McIntire, Principal Norwood High School, Norwood, Ohio; *Vice-President*, Charles H. Perrine, Principal Wendell Phillips High School, Chicago, Ill.; *Secretary*, Anna Willson, Principal High School, Crawfordsville, Ind.; *Department of Higher Education: President*, Guy Stanton Ford, University of Minnesota, Minneapolis, Minn.; *Secretary*, J. J. Pettijohn, Director Educational Extension, Bureau of Education, Washington, D. C.; *Department of Normal Schools: President*, John R. Kirk, President State Normal School, Kirksville, Mo.; *Secretary*, Anna M. Tibbetts, Fargo College, Fargo, N. D.; *Vice-President*, Joseph Rosier, President Fairmont State Normal School, Fairmont, W. Va.; *Department of Science Instruction: President*, George R. Twiss, Ohio State University, Columbus, Ohio; *Vice-President*, James H. Smith, Assistant Principal, Austin High School, Chicago, Ill.—719.

MISSOURI SOCIETY OF TEACHERS OF MATHEMATICS AND SCIENCE.

Department of Mathematics and Science: President, O. M. Stewart, Columbia, Mo.; *Secretary*, B. F. Finkel, Drury College, Springfield, Mo.; *Treasurer*, A. J. Schwartz, St. Louis, Mo.; *Mathematics Division: Vice-President*, W. A. Luby, Kansas City; *Secretary*, Eula Weeks, St. Louis, Mo.—419.

NEW ENGLAND ASSOCIATION OF CHEMISTRY TEACHERS.

President, William W. Obear, High School, Somerville, Mass.; *Curator*, Lyman C. Newell, Boston University, Boston, Mass.; *Secretary*, S. Walter Hoyt, Mechanic Arts High School, Boston, Mass.; *Treasurer*, Alfred M. Butler, High School of Practical Arts, Boston, Mass.—120.

NEW ENGLAND ASSOCIATION OF TEACHERS OF MATHEMATICS.

President, William R. Ransom, 29 Sawyer Ave., Tufts College, Mass.; *Vice-President*, Edmund D. Searles, High School, New Bedford, Mass.; *Secretary*, Harry D. Gaylord, 448 Audubon Road, Boston, Mass.; *Treasurer*, Harold B. Garland, High School of Commerce, Boston, Mass.—1218.

NEW JERSEY SCIENCE TEACHERS' ASSOCIATION.

President, Merton C. Leonard, Dickinson H. S., Jersey City; *Vice-President*, Walter J. Dumm, Barringer H. S., Newark; *Secretary-Treasurer*, Carl J. Hunkins, South Side H. S., Newark; *Recording-Secretary*, Agnes V. Luther, Newark Normal School, Newark; *Chairman Biology Section*, F. H. Hodgson, High School, Montclair; *Secretary Biology Section*, Miss L. H. Seeley, Dickinson H. S., Jersey City; *Chairman Chemistry Section*, C. E. Dull, South Side H. S., Newark; *Secretary Chemistry Section*, Miss Pauline McDowell, Battin H. S., Elizabeth; *Chairman Physics Section*, W. H. Platzer, High School, Kearny; *Secretary Physics Section*, Carl O. Voegelin, Central C. & M. T. H. S., Newark; *Chairman Elementary Science Section*, Miss Edith L. Spencer, South Side H. S., Newark; *Secretary Elementary Science Section*, Miss Julia G. Pierce, High School, Paterson; *Members at large of the Executive Committee*, Dr. M. T. Cook, Rutgers College, New Brunswick, and Miss Edith S. Merritt, Dickinson H. S., Jersey City.—120.

Digitized by Google

Vol. XX. No. 4 S37 S4 Whole No. 168

APRIL, 1920

SCHOOL SCIENCE AND MATHEMATICS

A Journal for All Science and Mathematics Teachers

Founded by C. E. Linebarger

SMITH & TURTON, Publishers

Publication Office, Mount Morris, Illinois

CHICAGO OFFICE, 2059 East 72nd Place, CHICAGO, ILL.

CHARLES H. SMITH
EDITOR
Hyde Park High School, Chicago

CHARLES M. TURTON
BUSINESS MANAGER
Bowen High School, Chicago

DEPARTMENTAL EDITORS

Agriculture—Aretas W. Nolan
The University of Illinois, Urbana, Ill.

Astronomy—George W. Myers
The University of Chicago

Biology, Research in—Homer C. Sampson
The Ohio State University, Columbus

Botany—Wonolo Whitney
Hyde Park High School, Chicago

Chemistry—Frank B. Wade
Shortridge High School, Indianapolis, Ind.

Chemistry, Research in—B. S. Hopkins
The University of Illinois, Urbana, Ill.

Earth Science—William M. Gregory
Normal Training School, Cleveland, Ohio

General Science—Fredric D. Barber
State Normal University, Normal, Ill.

Mathematics—Herbert E. Cobb
Lewis Institute, Chicago

Mathematics Problems—Joseph A. Nyberg
Hyde Park High School, Chicago

Physics—Willis E. Tower
Englewood High School, Chicago

Physics, Research in—Homer L. Dodge
The State University of Oklahoma, at Norman. Representing American Physical Society

Science Questions—Franklin T. Jones
Warner and Swasey Co., Cleveland, Ohio

Zoology—Harold B. Shinn
Schurz High School Chicago

Published Monthly October to June, Inclusive, at Mount Morris, Illinois
Price, $2.50 Per Year; 30 Cents Per Copy

Entered as second-class matter March 1, 1913, at the Post Office at Mount Morris, Illinois, under the Act of March 3, 1879

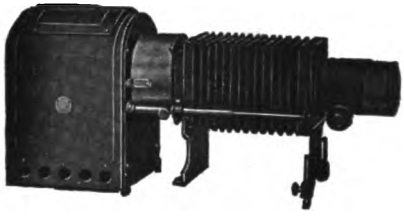
Digitized by Google

"McIntosh Lanterns Are Honest Lanterns."

Lantern Slides of Science

A copy of our Catalogs of science slides was mailed when published to every member of the Central Association. Are you a member? Did you get your copy? Did you keep it?

If not, there is another copy for you if you are interested. Just write us a card and ask for it. No obligation. You'll need it in placing your orders for science slides.



Lanterns from $36.00 up. Opaque and micro projectors, slides and accessories.

McINTOSH STEREOPTICON COMPANY
410 Atlas Block, CHICAGO, ILL.

For Next Semester

Moore and Halligan—PLANT PRODUCTION
—Agronomy and Horticulture

Mayne and Hatch—HIGH SCHOOL AGRICULTURE
—General Treatment

Coulter—PLANT LIFE AND PLANT USES
—Practical Botany—Not too Technical

Hunter—CIVIC BIOLOGY
—Community Welfare

Dryer—HIGH SCHOOL GEOGRAPHY
—Physical—Economic—Regional

Clark—INTRODUCTION TO SCIENCE
—A real general science.

New York
Chicago
Cincinnati
Boston
Atlanta

AMERICAN BOOK COMPANY
330 East Twenty-second Street
CHICAGO, ILLINOIS

Digitized by Google

SCHOOL SCIENCE AND MATHEMATICS

VOL. XX, NO. 4 APRIL, 1920 WHOLE NO. 168

SOME FACTORS AFFECTING THE SELECTION OF THE HIGH SCHOOL COURSE OF STUDY AND METHODS OF TEACHING OF MATHEMATICS.

BY H. R. DOUGLAS,

Professor of Secondary Education, University of Oregon.

THE THEORY OF FORMAL DISCIPLINE.

Mathematics is one of the oldest subjects in the curriculum of secondary schools. It constituted a very important branch of study as far back as the early Egyptian civilization thirty centuries ago. The scholars of the Hindus, the Chinese, and the Greeks were mathematicians, and the study of mathematics was an integral part of the learning of those peoples. Arabian civilization emphasized mathematics and left to us very important additions to the science. All through the middle ages, mathematics, along with the classical languages, occupied a considerable time and place in the studies of the schools of the times. From the time of John Sturm's gymnasium to the present, mathematics has been looked upon as one of the primary subjects of education.

Until recently its place has never been doubted or its values questioned. Aside from its utilitarian, its preparatory, and its cultural values its supposed value as a disciplinary agent has been considered enough to insure its retention. It has been perhaps this value that has been most emphasized. All through the past centuries mathematics has been looked upon as being with the languages the chief trainer of the mind. Because of the importance attached to this value of the study, the material has been chosen with little else in mind than a systematical, logical presentation of the field of mathematics. Depending as it has upon the theory of formal discipline, there has been for a long period of time but little change in the subject matter and methods of teaching as little there might need be in such a case.

Digitized by Google

In the last century there has appeared a tendency to consider more and more seriously its other values. It is becoming fundamental that the subject function directly and definitely if it should retain its prestige. Business arithmetic and the mathematics of physics are examples of this principle. Not only must the subject of mathematics train the mind, but it must also be taught so as to be of practical value in actual life. This tendency was wonderfully augmented by the tremendous force with which the older theory of formal discipline has been attacked in recent years.

In their history the theory of formal discipline and mathematics have had much in common and have been interrelated closely. Immediately upon the working out of the subject matter of mathematics, that is, immediately after sufficient material had been worked out to make mathematics an organized branch of study it was taken under the wing of formal discipline. Mathematics was used to sharpen the intellect; a material for mental practice to produce mental keenness. Plato in his *Laws* sets forth the value of mathematics in the following words:

"No single statement of youthful education has such a mighty power both as regards domestic economy and politics, and in the arts, as the study of arithmetic. Above all, arithmetic stirs up him who is by nature sleepy and dull and makes him quick to learn, retentive, shrewd."

All through the ancient and medieval career of mathematics and the formal discipline school, the cause of one has been the cause of the other, and together they weaken in the recent present under the onslaught of common criticism. The place of mathematics in the high school curriculum depends, as it is now organized, to a considerable extent upon the amount of the transfer of training. The question of the transfer of training is an open question. During the twenty years just past much attention and thought has been devoted to the discussion; as yet there is no exact agreement among any considerable number of recognized authorities. The leading students of education and psychology have practically all set forth in some manner their belief in the matter, either explicitly or impliedly. Out of the affair there seems to arise one theory stronger perhaps than all others but as yet only a theory. While some little experimental evidence seems to corroborate it, actual conclusive proof is only begun. This is the theory of identical elements. It is probably best stated by Thorndike who stands sponsor

Digitized by Google

for it: "Improvement of any one mental function or activity will improve others only in so far as they possess elements common to it also." He explains that identical elements may be either elements of procedure, or elements of substance. Henderson, Heck, O'Shea and a number of others lean toward this hypothesis and it is implied in educational practice widely.

At any rate it is pretty well recognized that whatever function is to be trained must be trained in situations as nearly like those in which it will be expected to function as possible. We may add to this another precept, which is a recent contribution from the investigation made in this field, namely, that the connection between the situation in which the training is being made to the possible situations of applications must be pointed out and emphasized at the time of training. For instance, to insure that the Pythagorean formula will function most efficiently in the life of the pupils, its possible practical applications must be pointed out to the pupil in the process of learning. In the case of the development of an ideal through a special field, the attention of the pupil must be directed to the operation of that ideal in other particular fields and in fields in general.

If this idea of discipline be accepted much that is now algebra, geometry, and trigonometry as taught in high schools will find itself on foundations of sands. Those portions of these subjects that do not have much in common (identical elements) with the future life of the pupil will be most likely to disappear from the course of study. Already we have courses in general mathematics being organized, the starting point in which is situations in everyday life. Smith somewhere claims that if only such mathematics is to be taught as will be of actual practical use later on, two-thirds of the present subject matter will be eliminated. That a great deal of this material might well be omitted is a fact worthy of consideration. However, much of this material must be retained on the basis of its value in developing other mathematical facts and principles, which do possess the value of utility.

The tendency is away from pure mathematics and towards applied mathematics, as should be especially in view of the more recent ideas on discipline. Efficient discipline necessitates the use of situations in teaching similar to those that will occur in the future life of the pupil. Textbooks will be accordingly modified. Mathematics as applied to industry, business, and other phases of vocational life will become the new order.

Digitized by Google

The organization will be from the basis of life problems, and such mathematics will be used as will solve them. Knowledge and skill in mathematics will be acquired from situations similar to those in which they will be used. Learning mathematics will tend to relieve itself of its analogy to the situation of learning to swim out of water. True development of the control can be brought about only in the presence of the medium to which the control is to be applied.

College Entrance Requirements.

The influence of greatest strength perhaps upon the shaping of high school curricula in mathematics has been the college entrance requirements. It has been the chief purpose, whether avowed or implied, of a far too large proportion of secondary schools to prepare for college. In fact the secondary school came well near being termed the preparatory school. The effect of the college upon the high school has been of serious strength and importance. High school textbooks have been written almost uniformly by college professors and almost as uniformly from the viewpoint of college standards of scholarship and with the lack of teaching psychology. High school teachers are, in the main, college graduates with ideals of college scholarship and with methods of college teaching fresh in mind. The composition of the secondary teaching force and teachers has done much to shape the course of study and determine methods of teaching in the high school. A third source of college influence, that of the college entrance requirements, has for decades shaped the educational policies of secondary schools. If the tendency has been to require two units of mathematics for instance, the tendency has been among high schools to offer, if not to require, that amount of mathematics for graduation. If but two years, one of algebra and one of geometry are required by the college then these two units are likewise offered or required by the high schools.

However powerful these three factors of college domination have been in the past, events have taken place in the last decade to assure one that this influence is waning. High school texts are beginning to be written by successful high school teachers. One of the most popular high school algebras is written by a triumvirate, two of whom are teachers of mathematics in high schools in western cities.

With the rise of teachers' colleges and chairs and department

Digitized by Google

of education in colleges and universities, high school teachers are beginning to employ methods of teaching more suitable to adolescents than the college methods they have been imitating in the past. They learn that while method and psychology are not of fundamental importance to the college instructor, they are more less fundamental in teaching mathematics to the high school pupils.

But chief of these forces operating to weaken the influence of the college among secondary schools is the receding of the committee on college entrance requirements from a dictatorial attitude. Whefeas, a few decades ago, at least three units of mathematics were required for entrance to the most colleges and universities, only two are now required by a majority of higher schools, and some are in the front rank of a coming movement and require no mathematics at all except for entrance to certain departments in schools.

In making up our high school courses in mathematics we need not feel called upon to insist upon the traditional course for reasons of college domination. If it becomes necessary to change or rearrange the time spent on algebra and geometry for utilitarian or disciplinarian reasons we need not hesitate to do so for fear of maladjustment with the higher schools.

What Shall Be Included?

There arises the question: Who knows, and how shall we determine what to include in a course of study organized on the basis of life problems? The answer is pointed—no one knows. It is a matter that remains yet to be worked out. It is very probable that there will never be more than a general agreement on the point. But it is certain that improvement will be rapidly made upon the present practice of teaching mathematics in its entirety, treating all parts impartially, regardless of present or future importance, and with little attention paid to the applications that can be and are made of the various elements of the subjects.

How shall we set about to determine what are the things desirable to be taught, emphasized, applied, etc: what elements are most identical with situations of life? Which are of most disciplinary value, and which prepare best? Suppose, for a moment, that we had no schools, no traditional courses of study, no traditional subject matter within those courses and no traditional methods of teaching: What would be correct *modus operandi* of formulating a course of study?

Digitized by Google

It is not unlikely that, first of all, we should turn back and examine for what purpose we wish to establish and maintain schools. We examine the numerous statements of the aim of education. We find that they are as various as they are numerous. Upon one point however they are all agreed. Education should be a process by which individuals should be changed or developed into individuals somewhat different. That is, they all set as the goal of instruction, the changing of an individual from what he is to what he should be. The points of difference are as to what he is, what he should be, and how the change may be best brought about.

Teachers of mathematics must show that mathematics aids essentially in developing an individual from what he is, to what he should be or mathematics cannot be included in such a curriculum. Mathematics to be best insured its place in the curriculum must be organized so as to contribute the most possible to such development.

The individual to be changed is the high school boy and girl, the adolescent. What he is educationally is the totality of his ideals, desires, likes, opinions, ambitions, purposes, instinctive and habitual goals—his values, and his method of behaviour, his powers, capacities, weaknesses, intelligence, knowledge, abilities, his means of control of values.

Values of Society.

What he is to become, is the goal of education. What is this goal in definite terms? What the values worth while are, and how they may be attained, has always been a point for discussion and investigation. Below we find a number of the aims of education of different nations and leaders which are the formulations of the values thought to be most worth while by those nations and leaders, and which we should probably examine before settling in our minds on a system of values.

Aims, Past and Present, of Education.

1. Egyptian—to train priests and scribes.
2. Chinese—to preserve the past, prevent change, and hand down Confucianism.
3. Hindu—to prepare for life to come.
4. Hebrew—to train in religion and morals.
5. Persian—to produce soldiers.
6. Greek—(a) Prehistoric—to make pupil wise and eloquent in council, and strong and courageous in battle.
   (b) Spartan—to make hardy warriors and patriotic citizens.
   (c) Athenian—to develop personality and live happily.
7. Socrates—to develop individuality in power of thought.

Digitized by Google

8. Plato—to determine what each individual is best fitted to do and then to prepare him for that service.
9. Aristotle—to provide properly equipped and properly disposed citizens.
10. Roman—to train for the professions.
11. Early Christians—morality and self denial.
12. Scholasticism—to systematize and master knowledge; to train the logical power and ability to dispute; to strengthen faith by the development of reason.
13. Renaissance—free development and liberal culture of the individual in the spirit of the revival.
14. Vittorino da Feltre—to prepare for a useful and balanced life in leadership in State and Church.
15. Sturm—piety, knowledge, eloquence.
16. Humanistic Realism—to master his own environing life, material and social, through a knowledge of the broader life of the ancients.
17. Jesuits—to strengthen the authority of the papacy and combat Protestant theories.
18. Milton—to fit a man to perform justly and skillfully and magnanimously all the offices both private and public of both peace and war.
19. Nulcaster—to aid nature in perfecting the mental and physical development of the pupil.
20. Comenius—to assist in attaining eternal happiness with God.
21. Locke—to fashion the carriage and form the mind, to settle in the pupil good habits and the principles of virtue, to give him, little by little, a view of mankind and work into him a love and imitation of what is excellent and praiseworthy, and the prosecution of it to give him vigor, activity and industry.
22. Pestalozzi—the natural, progressive and harmonious development of all the powers and capacities of the human being.
23. Herbart—to establish moral life or character.
24. Spencer—to prepare for complete living.
25. Horace Mann—moral character and social efficiency.
26. Eclectic Aim—a type of mind that includes power of rational insight.
27. Dewey—to remake experience, giving it a more socialized value through individual experience, by giving individual better control over powers.
28. Strayer—to form habits of thought, feeling, action, acquiring knowledge of nature and society, forming ideals which make for social well being, learning to act independently, to function in society.
29. Butler—"these five characteristics then I offer as evidence of an education—correct and precise use of the mother tongue; refined and gentle manners, which are the expression of fixed habits of thought and action; the power and habit of reflection; the power of growth; and efficiency or the power to do.
30. Brown—the harmonious development of human power for a life of service in the society and state, with due regards for peculiar needs, inclinations of the individual as far as his own happiness and his social efficiency are concerned.
31. Parker—social efficiency, good will and the harmless enjoyment of leisure time. (Broad ultimate aims)—health, information, habits, ideals and abiding interests. (Detailed or immediate aims.)
32. Inglis—vocational, avocational, civic.

The foregoing aims or purposes of education, as might be expected, show extreme variability. This is due to a number of causes. Ideals and conditions of society change from time to time, and vary widely among individuals and groups at the same time. The conception of the function of the school has

Digitized by Google

varied widely from time to time and with different people and peoples. The school's share in the education of the young has been a matter subject to change, varying with the scope of the church, home, street, and other social organizations. In the last analysis, however, we will find that the function of the school is to assist the individual in getting before him the values of society and in acquiring the greatest amount of efficiency in the technique of controlling these values.

As we have found a variety of opinion concerning the aims of education, we shall expect to find a variety of opinion as to what are the values of society, and a greater variety as to what is a correct ranking of them in importance. Following is a list of values of society, perhaps not at all exhaustive, surely overlapping, and surely not a set upon which any startling uniformity of opinion might be secured, yet certainly adequate in the main as a classification serviceable as a basis from which to work.

1. Health or vital efficiency.
   a. Ability to avoid disease.
   b. Ability to build up the body.
   c. Ability to improve transmittable characteristics.
2. Economic efficiency.
   a. Ability to provide a living for self and dependents.
   b. Skill in conserving and disposing of goods.
3. Moral efficiency.
   a. Self control.
   b. Correct ideals—(ideals conducive to the best interests of individual plus society).
   c. Correct influence and example for others.
4. Social efficiency.
   a. The quality of being an agreeable unit in society.
   b. Insight into purposes and characteristics of social body.
   c. Spirit of coöperation and technique of same.
   d. Appreciation of harmless or profitable enjoyment.
5. Civic efficiency.
   a. Intelligent exercise of franchise.
   b. Intelligent discharge of official duties.
   c. Patriotism.
   d. Law-abiding qualities.
6. Mental efficiency.
   a. Cultivation of powers by disciplines.
   b. Healthful mind.
   c. Wide, rich, varied experience.
7. Religious efficiency.
   a. Development of adequate philosophy of life and immortality.
   b. Self-direction.
8. Domestic Efficiency.
   a. Home-making.
   b. Rearing and care of young.
   c. Marital agreeability.

These are the values for which we are to work. What have we to work with? We have on the one hand the children to be educated, upon the other, the mathematical experience of the

Digitized by Google

race. We must assume that those who essay to teach mathematics have an adequate hold upon this experience. We should be in a position to assume that they likewise have an adequate knowledge of the nature and development of children. But it is far from likely that such is the case. It is a fact that teachers collectively possess far more adequately the necessary subject matter qualifications than they do those pertaining to a knowledge of the children they are to teach.

We have said that education must function to develop the individual from what he is to what he should be. We might have said that education serves to develop from the values and controls of the adolescent, the values of society and the controls of the same.

The Values of the Adolescent.

So far we have only set up the values of society. Let us now suggest some of the values of the adolescent. For this discussion we shall rely largely upon our conclusions from a reading of G. Stanley Hall's "Adolescence." The following is a classification of a number of adolescent values reduced to somewhat general heads. Under each is listed a few typical controls the adolescent has of that particular value.

1. Pleasurable activity.
   Music, dancing, play, companionship of other sex, of own sex, organizations, college life, stories.
2. Development.
   Exercise, play, school, companionship, ideals, adult society, nature, courage, ownership, vocations, and dancing.
3. Excitement.
   Music, dancing, leadership, myths, biography, religion, other sex, pugnacity, play, stories.
4. Prowess.
   Play, other sex, physical bigness, leadership, adult society, ownership, slang.
5. Excellence.
   School, play, music, religion, dancing, activity, ideals, vocation.
6. Sociability.
   Adult society, cliques, organizations, other sex, school, college life.
7. Approbation.
   Adult society, school, parental association, play, music, dancing, courage, physical prowess and growth, ownership, slang.
8. Rationality of nature and human artifice.
   Nature, science, commerce, government, industry, history, biography in the matters of cost and building.

Mathematical Controls.

In attaining economic efficiency a larger field of usefulness presents itself to mathematics. Vocations of all sorts depend somewhat upon the manipulation of number, and usually upon

Digitized by Google

a conception of space and figures. This, of course, varies. The surveyor, for instance, needs considerable knowledge and training of a mathematical nature, the hod-carrier not so much. Economic efficiency depends also upon disposal and conservation of income as well as the obtaining of it. Life insurance, banking, all sorts of investments need a higher type of mathematical proficiency than is obtained from a study of the four fundamentals.

That mathematics contributes to moral efficiency in any large degree might be open to question. Yet no subject in the curriculum puts such a premium upon truth and accuracy as does mathematics. Ideals such as neatness, accuracy, speed may be developed from all parts of mathematics.

Social efficiency demands culture. That such is obtained from mathematics in general is at least plausible. Its value, however, depends somewhat upon the subject's being accepted as culture. Again in order to understand social facts and principles, a sense of proportion responsive to stimulation by statistics and graphs is necessary. To be socially efficient one must understand social institutions. Business arithmetic affords a well worked out starting point and basis for the study of business institutions, practices and devices. Socialized arithmetic belongs not to the elementary grades as experience will show, but should be presented at a later time when the pupil has arrived at that age when by means of a better developed social insight, he is capable of assimilating and appreciating social information.

Civic efficiency again brings us to the subject of statistical representation. A knowledge of graphs and an appreciation of the relativity of numbers is necessary to the best understanding of articles and books bearing on civic and governmental questions and political issues.

Mental efficiency, a condition of having a mind and mental development well suited and well trained for the situations to be experienced by the individual, calls for, among other things, a rich, wide, and varied experience. Mathematics may well be made the means of presenting this experience, and in itself, by virtue of its being a language in itself, colors and vitalizes experience by grouping it into classifications and laws expressed in mathematical formulas. Again, methods of procedure in mathematics furnish a valuable source of disciplinary training, the identical element being the method of procedure.

Religious efficiency of all the values has perhaps least hope

Digitized by Google

of realization in mathematics though it is through the treatment of the infinite that one may best get an adequate idea of eternity, of a Supreme Being who has neither beginning nor end.

Domestic efficiency, a field of recent development, would find necessary training in measurement and tabulation, accounts and statistics. Home-making requires a knowledge of dietetics and sanitation—the former a study requiring some mathematical technique, the latter requiring the mathematical controls referred to under the value of health efficiency.

From the foregoing, the reader might easily be led to underestimate the value of mathematics as a method of control of the desired values. This is due partly to the fact that the author in pointing out controls has not considered it within the bounds of time and space in this paper to go into detail, but rather has let the matter go at making general suggestions as to possibilities. Another consideration that operates to leave that impression is the very nature of the function of mathematics. It is rarely a control in itself. It is a tool subject. It furnishes control of certain elements necessary to controls. Its functions variously stated. In substance its function is to acquire proficiency in handling number and space. Rarely do we find the problem of handling number and space a direct control. More often we find it a method of assisting or of making more easy or clear other direct controls. A knowledge of mathematics is fundamental in the sciences. Physics without algebra would be of small value compared to its actual worth, as its quantitative aspect is an essential in its use. The equation in chemistry is elemental. Botany, astronomy, agriculture, zoology, anatomy, bacteriology—all the sciences have been more or less obligated to mathematical controls for the working out of the science, and depend somewhat upon them for a clear understanding and adequate application of their principles and facts.

Architecture, all branches of engineering, medicine, manufacturing, contracting—all put a premium upon mathematical controls. The mistake we make is in assuming that ordinary efficiency in ordinary situations is all that need be provided for and that all else may be left for special training in higher schools. We can not neglect the fact that it is the small margin of efficiency that marks the leader from his followers. The leader, the investigator and pioneer in the field of discovery and develop-

Digitized by Google

ment often rises from the ranks of those who did not have the opportunity of higher study.

Vocational Guidance.

There arises the question, however: How is the freshman or sophomore in the high school to know whether the calling he is to follow will demand of him any especial mathematical ability? The answer is this. In acquiring the knowledge essential to all in the courses of the first and second year he should find opportunity to estimate somewhat his predilections and would be by the end of, say, two years of mathematics, in a position to know his mathematical aptitudes, abilities, and interests. If he finds that mathematics does not interest him, and is of especial difficulty to him he should know that it probably will not be the wise thing to specialize in the field. If, however, he finds that the field is highly interesting and does not give him any serious difficulty, it is probable that he should go farther into the field and turn his attention towards the vocations that put especial premium upon efficiency in mathematics.

It is not likely that the average boy or girl will discover these things and their conclusions therefrom unaided. In the first place he has not an adequate conception of what constitutes superiority in mathematics, outside of his immediate school group. But more pressing is the need of having some method of coming into the necessary information concerning the vocations themselves. We are guilty of the inconsistency of removing our boys and girls from touch with the vocational life of the world, calculating to aid them, by revealing them to themselves through their studies, to find their most suitable work, leaving them to pick by whatever means, limited, accidental, unreliable, they can, the necessary information of vocational requisites and returns. We have evaded the issue. Vocational guidance is more than an evaluation of the abilities and interests of the child. The other side of the equation, at least, equally important must receive attention. We can not expect boys to secure any adequate conceptions of the things they should know of vocations on the streets or in the home. For instance, the boy excels in his high school mathematics. He feels, rightly, that he should make the most of his gift. He knows that in his relations with the grocer, the element of most importance has been of measures and money. He may straightway erroneously conclude that he will find in that business the fullest opportunities for mathematical ability. The knowledge that the

Digitized by Google

adolescent acquires concerning vocations is usually very much like the experience of the blind men with the elephant. In fact it approaches a fixed rule that the vocations most attractive to boys of the adolescent period are those which are of least likelihood to prove the most worth while; blind alleys and overcrowded types.

Teachers of mathematics should strive to make themselves sources of information and advice to those of considerable mathematical talent in order that the full possibilities of such may be best conserved and utilized for society and the individual. This should be done by proper educational and vocational guidance. Likewise, those of very limited possibilities in a mathematical way should be directed to other channels as also should those who possess mathematical talent beyond ordinary but who possess other qualities unfitting them for the fields in which mathematical ability is of most value.

Conclusions.

It seems worthy of consideration to the author that:

1. Courses of study and methods of teaching in mathematics cannot continue to look to the theory of formal discipline for justification.
2. They should not look to that theory for a basis of selection and organization.
3. They should not look to college entrance requirements for justification.
4. They should not look to college entrance requirements for a basis of selection or organization.
5. Courses of study and teaching methods in mathematics should be governed in selection and organization by the aims of education and the functions of the high school and should, therefore, be so selected and organized as to contribute directly to common life situations and social values.
6. Mathematics, properly organized and taught, contributes heavily and directly to the important social values.
7. The propaedeutic or preparation function of mathematics is of next importance and is likely to be underestimated.
8. The course of study and methods must also be so selected and organized as to conform to an appeal to adolescent interests, abilities and controls.
9. The possibilities of vocational and educational guidance should not be neglected by the teacher of mathematics.

Digitized by Google

SECOND LIST OF MARGINAL NOTES ON CAJORI'S HISTORY OF MATHEMATICS.

By G. A. MILLER,
University of Illinois.

In a preceding volume of this journal, Dec. 1919, page 830, the writer gave a brief list of suggested marginal notes on the revised and enlarged second edition of Cajori's *History of Mathematics* in the hope that such a list might prove especially useful to teachers who would make use of this important work in connection with their classes. Having incidentally found a considerable number of additional statements in this work which seem to call for comment the writer offers herewith a second list of such notes with somewhat more details so that this list may be of greater interest to those who do not have on hand the work under consideration.

The fact that these two lists cannot be expected to present a complete collection of desirable comments becomes evident if it is recalled that about two thousand such notes, relating to the largest history of mathematics in the German language, appeared in various numbers of the *Bibliotheca Mathematica*, while these two lists contain scarcely one-tenth of this number. Moreover, the German work is confined to the history of developments in our subject up to the beginning of the nineteenth century while Cajori's work relates to the entire history of this subject. The notation employed in the present list is the same as that used in the preceding list.

Page 4, line 13: "In the Babylonian notation two principles were employed—the additive and multiplicative." Lower on the same page it is correctly stated that some of the Nippur tablets exhibit the *subtractive* principle. The former of these two statements appears also in the old edition of Cajori's *History* and was perhaps in accord with all that was known when this edition was prepared, but it does not convey the correct impression as regards all that was known when the second edition was prepared as results from the added statement noted above. This is an instance of a considerable number of somewhat discordant statements found in the second edition which can be readily explained by referring to the first edition but are otherwise perplexing.

On the same page there appears the statement that "some of the cuneiform numbers found on tablets in the ancient temple

Digitized by Google

library exceed a million." This is correct but when it is noted that unit fractions of the number 195,955,200,000,000 are found here it is evident that this excess over a million is more considerable than would likely be inferred from the quoted statement. According to H. Wieleitner, *Der Begriff der Zahl*, 1911, page 5, the number 195,955,200,000,000 is probably not the largest which appears on these tablets.

Near the bottom of this same page it is stated that "we possess two Babylonian tablets which exhibit this use," referring to the use of the sexagesimal system of notation. This statement is also found in the old edition, and it represented a fairly accurate statement when the first edition appeared, a quarter of a century ago; but since 1906 a large number of additional tablets containing numbers written in the sexagesimal have beome known, especially through the labors of H. V. Hilprecht, who described over forty such tablets in his *Mathematical, Metrological and Chronological Tablets from the Temple Library of Nippur*, 1906.

Page 5, line 21. In speaking about the Babylonians the following question is asked: "Had they already taken the gigantic step of representing by a symbol the *absence* of units?" It is a question whether the use of a symbol to represent the *absence* of units should be regarded as a gigantic step at the time of the Babylonians. According to H. Wieleitner, *Der Begriff der Zahl*, 1911, page 4, the Egyptians had a hierogliph for zero since the most ancient times. The use of zero as a number with which one can operate is a much more advanced concept than the use of a symbol to indicate the absence of units.

Page 35, line 18. Infinitesimals are not commonly defined as "infinitely small constants."

Page 43, line 4 from bottom. Instead of "found the irrational square roots" read "approximated the square roots."

Page 44, line 15. As Heron is classed with the Greek writers it is not exact to say "this may account for the fact that his writings bear so little resemblance to those of the Greek authors, who considered it degrading the science to apply geometry to surveying." The omission of the comma would tend towards a clearer presentation of the facts.

Page 57, line 3. The statement: "It was indeed a thought of extraordinary boldness, to assume that straight lines could exist, differing from one another not only in length—that is, in quantity—but also in a quality, which, though real, was absolutely invisible," seems too obscure, and the reference to Hankel

Digitized by Google

does not make it clear. In this reference the words *Mittelalter* and *Alterthum* should be interchanged.

Page 58, line 5. It is here stated that the seventh book of Euclid's *Elements* begins with twenty-one definitions. In *The Thirteen Books of Euclid's Elements*, by T. L. Heath, 1908, volume 2, page 277, there appear twenty-two such definitions. Moreover, Cajori adds that all of these definitions except that for prime numbers are known to have been givenby the Pythagoreans while Heath states on page 294 that the Pythagoreans used the term perfect in another sense, calling 10 a perfect number. On Page 56, Cajori also implies that the Pythagoreans used the term perfect number with its present meaning. It should have been stated that the later Pythagoreans did this but not those belonging to the early period of this school.

Page 60, line 21. Instead of "his age was eighty-four" write "his age at the time of his death was eighty-four."

Page 105, line 22. The sign of division is omitted in the latter fraction, and in the first line of the following paragraph the word "or" appears in place of the word "of."

Page 136, line 13. The word "general" should be added before "equations" in this line and other places in this paragraph. It is known that special equations of every degree can be solved algebraically.

Page 143, line 8 from bottom. The statement "that these proofs would lack rigor was almost to be expected, as long as no distinction was made between algebraical and transcendental numbers," is apt to mislead the reader since the quadrature of the circle by means of the unmarked rules and compass would be impossible even if π were an algebraic number, provided its value could not be found by rational operations and the extraction of a finite number of square roots.

Page 157, line 2. It seems too strong a statement to say that T. Harriot "brought the theory of equations under one comprehensive point of view," as a result of the fact that he recognized the relation between the roots and the coefficients. In fact, Cajori admits in the same paragraph that "he failed to recognize imaginary and even negative roots." A comprehensive point of view of the theory of equations without recognizing such fundamental properties seems impossible.

Page 158, line 10. According to the *Encyclopédie des Sciences Mathématiques*, tome 1, volume 1, page 40, the dot was placed after each number by some writers during the middle ages.

Digitized by Google

Hence this example does not prove that T. Harriot used the dot to denote multiplication.

Page 167, line 9 from bottom. The fifth perfect number is incorrectly stated here. It should begin with 3 instead of with 2. The same error is found in many other places. Cf. L. E. Dickson, *History of the Theory of Numbers*, 1919, page 13. The ninth perfect number was found by J. Pervusin before it was found by P. Seelhoff, loc. cit. p. 25.

Page 172, line 23. Instead of Simplicio read Simplicius. The former is the Italian form of this name. In other parts of the book the name is correctly given. Cf. pages 22, 23, etc.

Page 181, line 10. According to G. Loria the logarithmic spiral was the first curve to be rectified and hence the statement made here about the semi-cubical parabola is incorrect. Cf. *Johrbuch über die Fortschritte der Mathematik*, volume 28, page 48. The statement that van Heuraet carried the rectification of the hyperbola back to the quadrature of the hyperbola seems also incorrect since the former depends upon an elliptic integral.

Page 182, line 3. The statement that infinite series had been obtained "possibly by others" is quite misleading as may be seen by referring to page 127 and by recalling the use made by Archimedes of such a series.

Page 191, line 10. According to M. Cantor, *Vorlesungen*, vol. 2, 1913, p. 921, infinitesimal calculus was discovered during the half century 1615-1668. Newton and Leibniz discovered *formal* calculus.

Page 209, line 34. Instead of "Berlin" write "Leipzig." In the preceding paragraph derivatives are called differentials.

Page 220, line 5 from bottom. Year of birth of Jakob Bernoulli is here correctly given as 1759 while 1758 appears after his name in the index.

Page 239, line 26. The exponent of 2 should be 2^n instead of 2n.

Page 250, line 21. The curve whose equation is here given has a very different form from the one determined by the equation in the following line. The latter has three real asymptotes while the witch of Agnesi has only one such asymptote. Hence the statement that P. Fermat gave the former curve in the latter form cannot be correct.

Page 251, line 15 from bottom. These dates are not in complete accord with those found in tome 2, volume 6, of the *Encyclopédie des Sciences Mathméatiques*, beginning with page 1.

Page 254, line 14 from bottom. It is here stated that J. L.

Digitized by Google

Lagrange proved Fermat's last theorem for the case $n = 4$. On page 239 it is stated that L. Euler proved this theorem. As a matter of fact, a proof of this case is a direct consequence of the propositions that the sum or difference of two biquadrates is never a square, and these propositions were proved earlier.

Page 255. The symbols in the equations near the bottom of this page should be defined.

Page 310, line 2. The term "abbreviated notation" is used here instead of the technical term *abridged notation*, which is used later on the same page. To the names here given as those to whom this notation is due there should be added those of G. Lamè, and J. D. Gergonne. *Encyclopèdie des Sciences Mathèmatiques*, tome 3, volume 1, page 205; volume 3, page 299. Near the end of the first paragraph on this page the word "and" should be replaced by "or" in two instances.

Page 316, line 1 from bottom. Instead of H. B. Baker write H. F. Baker. Add page 1 at the end of this line.

Page 320, line 19 from bottom. This work of Teixeira was translated into French and much enlarged, appearing in two volumes, 1908 and 1909. The first initial of Dupin appearing in line 13 from the bottom should be F instead of E.

Page 356, line 4. In accord with most of the other names which are followed by biographical sketches this name should be Christian Felix Klein. It is interesting to note in this connection that in at least four editions of Ball's *History of Mathematics*, including the fifth edition, 1912, the initials of Klein are given as F. C. in place of C. F.

Page 358, line 2 from bottom. Instead of "only one" write "no."

Page 373, line 4. Instead of "this" write "the preceding." This is another instance where necessary changes were overlooked, as the same sentence appears in the old edition and was correct when that edition was issued. About the middle of the first paragraph there appears the statement that "the first important and strictly rigorous investigation of infinite series was made by K. F. Gauss in connection with the hypergeometric series." On the other hand, according to the *Encyclopédie des Sciences Mathématiques*, tome 1, volume 1, page 170, J. H. Lambert investigated rigorously the infinite series representing tan x. The statement that J. Wallis called this series the hypergeometric series is misleading since Wallis gave this name to an entirely different series which does not involve a variable.

Digitized by Google

UP-TO-DATE PROBLEMS IN JUNIOR HIGH SCHOOL MATHEMATICS.

By Theodore Lindquist,

Kansas State Normal School, Emporia, Kan.

More and more are mathematics principles studied for their applied values. Problems deserve special attention since they constitute the material for the application of the principles.

In the interest of the economy of time it behooves the teacher of mathematics to be continually on the alert as to how much application of any part of the work is necessary. Time is lost by making so few applications of a principle that no lasting impression results just as truly as time is lost by making too many applications of a principle clearly understood by the pupils. For instance, it has been found experimentally that in literal numbers addition and subtraction require little practice compared with multiplication and division. Another waste of time is the neglect of principles and operations, after they have been studied, to such an extent that they are lost sight of by the pupils. Unless principles and operations are used they will soon be forgotten, however well they were once understood. These necessary recurrences may often be arranged for as by-products of other problems. Drills in integers and common fractions can be arranged for in the verification of operations with literal numbers. After pupils have learned to multiply by 25, by annexing two zeros and then dividing by 4, let the teacher arrange to have multiplication by 25 come up often even though it is not provided for in the text used. This method not only gives practice in past operations but makes the pupil feel that each operation must be mastered since he knows he will encounter it later. Problems which require the use of past principles are also the chief aids in unifying the mathematics work of the junior high school, an object much sought after.

Forms of Problems.

First of all there are the exercises and drills as contrasted with the so-called thought problems. Such exercises and drills are essential in fixing the various operations studied. Included in these exercises must be ample practice in the four fundamentals with integers, common fractions, and decimals. The need by all of a facility in these fundamentals, together with the woeful lack too often shown by young people, makes such exercises most necessary. While it is true that the pupils should

Digitized by Google

have acquired a command of much of this work in fundamentals in the first six grades, still it is imperative that any lack be remedied in the junior high school, especially as many pupils leave school at the completion of the ninth grade. Furthermore, the demand of business for a facility in numerical expressions is a demand which we have no right to ignore.

Much has been written and said of the need of practical problems to most of which all agree heartily. Practical problems must not, however, mean only such as arise out of conditions confronting grown-ups. Not knowing into what walk of life a pupil may be drawn it is impossible to anticipate, except in a general way, the conditions that will confront him later. Hence, problems must be such as will likely come within the range of all after leaving school. For instance, every boy and girl should be acquainted with the elements of banking as carried on in the United States from the standpoint of the person outside but not necessarily inside of the banking counter. Most of us deposit money in banks and withdraw the same but very few of us are employed in a bank.

Good problems must first of all appeal to the pupils' interests. Hence, much material should be drawn from the pupil's own life and activities. Problems based upon child life, which in addition involve applications of mathematical principles and operations that will confront the pupils in the future, are in the truest sense practical. In a certain school the pupils computed the percentage standings of baseball, football, and basket ball teams. Here they found what per cent one number is of another, which involves the same process that they may later need in finding what rate of interest an investment nets. John Dewey maintains that problems "—need not give actual situations to be met with later, but the power to meet them." A happy mixture of problems dealing with child life and others with business will produce the best results. Those of the first class are more applicable to the earlier work in the junior high school while those of the latter class may be increased in number as the work progresses.

Most problems must, of course, be based upon stated data but it will be in the interest of the development of initiative to provide problems that contain no explicit data. "Problems without numbers," in which the pupils state the operations to be used, come within this list. In the junior high school it has been found that the best form is to ask for a statement of the opera-

Digitized by Google

tion by an equation, which is in the direction of both explicitness and generality. Again it should be mentioned that the best results from these problems can be secured by interspersing them with others rather than by giving them in groups by themselves. Pupils thrive best upon a mixed diet in the matter of problems.

Sources of Problems.

The chief source of problems is, of course, the text. An alert teacher will supplement these from time to time with others based upon local data and conditions. Sometimes the data of the text are merely replaced by local data. At other times wholly new problems may be suggested by those in the text or by some local interests. To secure actual data for all such problems will require too much time from the teacher nor is that necessary. Hypothetical data and conditions may be used providing they appear real to the pupils and are not at variance with actual practice. Freight cars have their capacity in pounds marked upon them as 30,000, 40,000, and so on. Hence a problem referring to a freight car with a capacity of 34,250 would be strained. Heavy loads as wagons or horses are weighed only te within 10 pounds and so the weight of a load of coal must nover be given as 5,716 pounds. It would be quite trite to mention here that all such problems should fit the pupils for whom they are intended as well as the season of the year in which they are to be solved, except for the fact that texts often violate these two primary essentials of good problems. Many teachers preserve all such composed problems in a card file to which additions are continually made. To let the pupils themselves secure the necessary data from questions, observations, readings, or measurements has proved to be a good plan. The radius of a tree can be found by measuring its circumference. The attendance of the classes in the school for a month can be compared from the attendance records of the teachers of the various classes.

Brief historical studies of our number system, of weights and measures, of the organization of some business institutions as banking or insurance, will all be found most interesting and helpful in the correlation of mathematics with other studies. As our civilization is based upon quantitive relations, such studies as these may well be termed introductions to a history of civilization. The interest may be increased by assigning topics to the pupils to be looked up further than the space of the

Digitized by Google

text permits and reported to the class later. Any attempt at describing the interest shown by the classes in this historical work will fall far short of the actuality.

Carrying out the idea of connecting the pupils' work into a unified whole, problem material may well be selected from their other studies, thus showing the direct application of their mathematics. Contemporary history, civic welfare, elementary scienence, manual training, and domestic science will supply much excellent material. Sports and other school activities, and home activities are additional fertile fields. Helpful lessons in industry and thrift can also form a part of the problem work. In this connection let us not forget the money value of an education, which ought to be taken up shortly before the pupils are completing the ninth grade, thus giving them an impetus in any desire they may have towards continuing their education in senior high school. It must be recognized at all times, however, that it is the application of mathematics that is sought through these problems and not "run to seed" making up courses in mechanics, applied economics, or the like to take the place of the mathematics course.

As far as possible it is best for a pupil to be acquainted with the complete situations under which a problem arises but that is not altogether necessary. Often much valuable time is lost and the pupils only muddled by explanations of situations in which excellent problem material comes up. In the evaluation of formulas it is preferable to tell a class that a certain formula is used by electrical engineers and then to ask the pupils to evaluate it for certain given quantities than it is to endeavor to give the class an understanding of the formula's particular use. The mere fact that it is a formula actually used by engineers in their work creates the necessary interest. Similar instances are very plentiful.

Mock activities are usually entered into with great enthusiasm giving the work vital interest. As an illustration may be mentioned a school bank. One day the writer observed a junior high school boy decidedly worried because he as receiving teller had accepted a number of checks that had not been properly indorsed.

Let no teacher overlook the valuable number contests in the junior high school. The pupils, especially of the seventh and eight grades, are far from too old to enjoy this form of activity and enter into it enthusiastically. Some form of contest is

Digitized by Google

particularly recommended for drill work. Before using any number contest it will be well for the teacher to apply to it the tests of a good number contest: (1) It must be simple for the teacher to operate; (2) it must create wholesome rivalry; (3) it must engage the attention of all of the pupils all of the time. Teachers have found it very helpful to divide the pupils of a grade into competing teams which were held permanent for a few weeks. In the first place it tended to create enthusiastic rivalry, but what was far more important, the good pupils on each team coached and gave other encouragement to the poor pupils on their respective teams in order to improve their chances in the contests.

Project-Problems.

An interesting as well as highly instructive process is the formation of problems by the pupils themselves. Project-problems, that are so much discussed at the present, come within this general type. The pupils investigate, as thoroughly as their ages and surroundings permit, some enterprise in which they have become expecially interested. Such an investigation may also, of course, be carried on by some one child of the class alone. Suppose that a class desires to investigate the reasons for the high rents in their community. It is first necessary to decide upon the type of house as to size and location that is to be investigated. The class is next divided into groups for interviewing the real estate agents of the community; this should be planned so that no agent is interviewed by more than one group. In these interviews the pupils ascertain the rents of houses of the general description previously decided upon together with the prices at which such houses could be purchased. After this comes the question of expenses connected with owning a house. This involves visits to insurance agents unless that data were collected during the interviews with the real estate agents. The tax collector must be seen regarding the tax rates and the valuation likely to be placed upon a house similar to the one in question. The estimated expense of up-keep must be secured from property owners or from their agents. Out of the data thus collected the net income is computed, and from this together with the estimated value of the house, the rate of interest such an investment would bring is found. A final investigation would now be to find from the banks and loan agents what would be a fair rate of interest upon money loaned at good security. Hence, the class can decide whether or not rents correspond properly with other expenses.

Digitized by Google

Seemingly trivial questions or discussions in class may often lead to first-class projects. The above mentioned project might have been the outcome of any problem on rents or the cost of houses. It should be noted that the above project itself suggests a number of others from time to time. The matter of purchase price may start an investigation of the cost of building. This could again be the source for drawing an architect's plan of a house; a study of the buying and manufacture of lumber; the making of contractors' estimates; and so on. The last part of the project opens up the whole field of thrift and investments. A class taught by a former student of the writer has investigated a hypothetical family budget. Each pupil selected his family, which could vary from three to five, together with the income of the family head. From the cost of rent, food, fuel, clothing, insurance, and incidentals, they made out their proposed family budget after reading articles discussing this matter in journals at home or in the library. While this may at first appear to the reader to lack actuality, it did not lack interest in the actual trial nor did it carry with it the undemocratic situation that would have arisen by the use of an actual budget from one or more members of the class. Paper routes, raising chickens, individual and school gardens, pig clubs, corn clubs, the school athletic association, and so on, will furnish much material for project-problems largely in the realm of mathematics. As project-problems depend wholly upon local conditions, it is obvious that texts can furnish only suggestions. A text problem on finding the volume of a city water tank might suggest a project in any city that contains a similar tank. The textbook study of land measure suggests a historical study of the same, a plat of the school grounds, measuring the area of the school grounds, and measuring the area of some other near by tracts. A railroad time table or a railroad map suggests the project of a visit to some interesting city, attendance at a convention, or a visit to a friend.

The simon-pure project springs from the pupil's initiative and that requires abundance of interest. For this reason only such investigations as come well within both the interests and the abilities of the pupils are to be encouraged. A project suitable for a ninth grade class will be oldish to a seventh grade class, nor can this class go into as difficult a project as can the ninth grade class. The above project on rents would be applicable to a ninth grade class. Conversely, a project highly commendable for a seventh grade class will likely appear simple and even

Digitized by Google

childish to a ninth grade class. In the above suggested list the project on raising chickens which may include building a suitable chicken house, expense of buying the first chickens, expense of feed, expense of increasing egg production, marketing eggs and poultry, the proper keeping of accounts, and so on, would be a suitable project for the seventh and ninth grades. Even though the initiative should come from the pupils, the good teacher, in yet more marked capacity than usual, must be the guiding hand in the background.

If correctly used so as to supplement and to apply the mathematics principles studied, projects can be made exceedingly valuable. They may be a large problem to which attention is given from time to time. The resourceful teacher will find many splendid problems coming up for solution throughout the progress of the project, sort of by-products, as may be noted in the illustration given above. These by-products furnish excellent reviews as they appear naturally and thus take the unprepared pupil unawares just as he will find problems arising in his future life. But valuable as this form of problems may be there is grave danger of overdoing them in the enthusiasm of taking up something that is new and over which much is made at the present.

The big province of junior high school mathematics in the realm of project-problems is not primarily a place for originating and carrying out large projects. Coming back to one of our former fundamental statements, the results of the great majority of investigations must be quantitative to be conclusive and useful, and mathematics will be needed to supply this quantitative conclusion. May we again direct attention to the necessity for a generalized mathematics in the junior high school as project-problems arise along all possible lines of study and endeavor throughout the school? One illustration must suffice. A general science teacher in a junior high school carried out a test of several samples of seed corn. Mathematics was needed in finding what per cent of each sample tested was seed, how far each was above or below a good average, how many bushels were lost per acre according to the previous year's yield in planting each of the poor samples, what this loss was in money per acre, and what the loss would be on a forty or an eighty acre field. The primary function of mathematics in the project-problems of the junior high school is, therefore, to furnish the instruments whereby the results of any investigation are made quantitative, hence, conclusive and useful.

Digitized by Google

ISSUE SCHOOL BONDS AT TULSA, OKLA.

At a special election held February 17, the voters of Tulsa, Oklahoma, authorized by an overwhelming majority the issuance of $850,000 of school bonds and the increase of the school tax levy to fifteen mills, the maximum allowable under the State Constitution.

This makes a total of $2,850,000 in school bonds authorized by the Tulsa electorate in the last five years. During this period all of the proceeds of the bond issues and a large share of the current revenue of the school system have been used for the purchase of sites, buildings, and equipment.

Since 1915 the scholastic enumeration in Tulsa has increased from 7,526 to 17,501. Fifty new rooms must be added annually to house the growing school population. The voters have never yet refused any request of the Board of Education for funds.

During the last three weeks the Chamber of Commerce, the Trades Council, the various civic organizations, the patron-teachers' associations, and the school children themselves conducted an active campaign of education to assure a large attendance at the polls yesterday.

Much credit is due to Superintendent E. E. Oberholtzer who, in his six years tenure, has established so close a cooperation between the school and the home that an awakened electorate throws its influence almost as a unit in favor of any measure designed to promote the welfare of Tulsa's educational system.

NATIONAL RESEARCH COUNCIL.

The Carnegie Corporation of New York has announced its purpose to give $5,000,000 for the use of the National Academy of Sciences and the National Research Council. It is understood that a portion of the money will be used to erect in Washington a home of suitable architectural dignity for the two beneficiary organizations. The remainder will be placed in the hands of the academy, which enjoys a Federal charter, to be used as a permanent endowment for the National Research Council. This impressive gift is a fitting supplement to Mr. Carnegie's great contributions to science and industry.

The Council is a democratic organization based upon some forty of the great scientific and engineering societies of the country, which elect delegates to its constituent divisions. It is not supported or controlled by the government, differing in this respect from other similar organizations established since the beginning of the war in England, Italy, Japan, Canada, and Australia. It intends, if possible, to achieve in a democracy and by democratic methods the great scientific results which the Germans achieved by autocratic methods in an autocracy while avoiding the obnoxious features of the autocratic regime.

The Council was organized in 1916 as a measure of national preparedness and its efforts during the war were mostly confined to assisting the government in the solution of pressing war-time problems involving scientific investigation. Reorganized since the war on a peace-time footing, it is now attempting to stimulate and promote scientific research in agriculture, medicine, and industry, and in every field of pure science. The war afforded a convincing demonstration of the dependence of modern nations upon scientific achievement, and nothing is more certain than that the United States will ultimately fall behind in its competition with the other great peoples of the world unless there be persistent and energetic effort expended to foster scientific discovery.

Digitized by Google

HOW DOES THE PRESENT HIGH SCHOOL COURSE IN CHEMISTRY MEET THE DEMANDS OF VOCATIONAL CHEMISTRY?

By Frank B. Wade.

Shortridge High School, Indianapolis, Indiana.

On first inspection of the title of this paper the author was tempted to exclaim, "There's no such thing as vocational chemistry in the high school!" On second thought however it was recalled that we are ourselves at Shortridge High School giving, for the first time this semester, a course in chemistry which is publicly announced as a course in "Vocational Chemistry." This course had its origin about as follows: For many years we have been filling from a dozen to fifteen positions a year with graduates of our one year course in chemistry. These positions have been in the nature of assistantships in practical laboratories in the vicinity of Indianapolis. The boys and girls have become chemists' apprentices or helpers. None of them should be called chemists, although several have shown such ability and application that they have been able to take over the work of college trained men during the absence of the latter during the war. The students that we sent to these places were picked boys and girls in most cases, although frequently our best students were not available to fill such positions as their plans took them immediately to college, which is as it should be. Moreover, it should be noted that it was only a dozen or so who thus obtained employment (nearly thirty last year because of the lack of adult workers on account of the war) from a department that has averaged about two hundred and fifty students during the past few years. Thus only a little more than five per cent of our students have been interested in immediately applying their knowledge of chemistry in a gainful way. Probably a rather larger percent than that have subsequently become chemists or chemical engineers or teachers of chemistry or in some way applied their chemical training after continuing it at colleges or technical schools.

We always strongly urge all pupils for whom we secure positions that they should save their money and go on to college, after a few years in the practical laboratory, if they hope ever to become real chemists, and many of them have done so.

All of this vocational work was done without specific training looking toward the work of the practical laboratory and this fact sheds much light upon the question of our title, for the

[1]Read at the University of Chicago Conference, May, 1919.

Digitized by Google

course we have been giving seems to have prepared our pupils fairly well for successful service in the practical laboratory.

A glance at the nature of the work now being done by a number of our graduates will show that it would have been folly to have attempted any but general training, so widely diversified are the tasks in the various laboratories to which we send them. One boy is acting as assistant chemist in the Water Company's laboratory. His work is largely biological. While he makes tests of the coal purchased by the company and nitrogen tests and a few other chemical tests such as those for chlorine, for minerals present in the water, etc. most of his work is bacteriological in character. We did not know that that boy was going to that particular laboratory until a few weeks before he was called. I then gave him an intensive course in the kind of work I knew he would have to do, that is, I gave him reference work which would enable him to understand the principles underlying the methods that I knew were in use in that laboratory. The technique I left to the chemist to teach.

Another boy went to a pharmaceutical laboratory where the work is almost entirely connected with organic chemistry and we teach very little of that. Several girls have gone to pharmaceutical laboratories where they have been put to testing hypodermic tablets. Several boys have been working in the laboratories of the local gas company where tests of coals, of gas, of benzol, etc. form their chief tasks. A large local engine works employs several of our graduates. The work there is mainly volumetric analysis of steels. One boy went to a rubber laboratory another to the Presto Lite Company. It can be readily seen that no course could be devised that would prepare all of these pupils for the specific work that they are called upon to do.

In a city with one preponderating industry employing numbers of pupils some such course might perhaps be planned but even then it may be doubted if it would be advisable. Practical methods change rapidly. The teaching of the industrial laboratory, where time is money and efficiency is a fetish, is bound to be more intensive, and effective in regard to specific method and routine than the more leisurely teaching of the schools.

There is no time in the one year high school course for specific training, in fact there is not enough time to teach thoroughly the underlying principles and theories of general inorganic chemistry. The practical laboratory certainly is no place to acquire these fundamentals. If the pupil does not get them in school he will probably never get them. Hence I say let the practical

Digitized by Google

laboratory teach specific methods and let the school prepare the student to be a rapid and intelligent learner, one who will want to know the why as well as the what of the routine methods of the laboratory to which he goes and one who will find out the why sooner or later with the help of the man over him. Such a student will be more likely to be advanced in the laboratory than one who merely does his day's work unthinkingly.

Now those of my hearers who have been reading between the lines of my subject matter can readily see why I was prompted to exclaim, "There's no such thing as vocational chemistry in the high school!" and yet you may be moved to demand, "Then why in the name of common sense are you offering such a course?'

Softly, softly, it's easier to fool a corporation than it is to fight it. Don't you know *vocational everything* is *the thing* just now? We must have it! So we offer it—but to whom and how? Only to pupils who have first made good use of the opportunities offered them in a thirty-eight weeks course of ten periods per week in general chemistry. To be admitted to Chemistry III as we call it, the recommendations of his chemistry teachers and of the head of department must be had by the candidate. He must also either have definitely in mind the use of his chemical training in a gainful way or else he must be intending to pursue chemistry in college. In the latter case the principal advantage to the pupil will lie in the opportunity that is afforded to apply and to keep freshly in mind some of the chemistry that he has already learned. We caution our candidates not to expect advanced standing in college on account of their work in Chemistry III.

At present we have some sixteen pupils, boys and girls, in Chemistry III. About half of them expect to go at once to college.

If I have dwelt at length on this vocational course of ours it is because, in planning it we were forced to think out an answer to the question that your chairman gave me to discuss. Our problem was of course, what shall we teach these boys and girls that they have not already got in their year of general chemistry? Through the author's memberships in the American Chemical Society, the Indiana Academy of Science and the Scientech Club of Indiana he was able to go to many college men and to many practical chemists for advice.

In reply to my question as to what we should teach the boys and girls whom we would send them in the future, the practical men without exception gave answers such as these: 1. "Teach them to have respect for figures, to be honest with their data,

Digitized by Google

never to 'doctor' their results." 2. "If you can teach them in three months to clean their glassware you can do better than we can in the laboratory." 3. "Teach them rapid and delicate manipulation of apparatus." 4. "Teach them to use the analytic balance rapidly and accurately and to read graduated measuring tubes and flasks etc." 5. "Teach them to think chemically, we'll teach them the specific routine after we get them in the laboratory."

It will be recognized that very little specific content of the course was suggested by these men who have been employing our pupils. With the exception of the request that we teach the use of the analytic balance and of graduated glassware the replies were all of a general nature. Our effort in our first year chemistry has always been to impress upon our pupils the things these men ask of those whom they employ and the degree of success that we have already enjoyed, as evidenced by the increasing calls for more graduates from the chemists who have used our boys and girls, would indicate that "the present high school course in chemistry" as given by us and by all forward looking institutions of like nature fairly well meets such demands as come to us from the real chemist who seeks a helper in his laboratory.

In closing you may be curious to know what sort of specific content we are using in our Chemistry III course. It is in the main an elementary course in volumetric quantitative analysis. We chose this material because it affords fine opportunities to apply chemistry that has already been learned by our pupils in their first year course. In making up and standardizing their own solutions they have an opportunity for considerable use of the analytical balance, they get splendid practice in the use of graduated glassware, there are many calculations from equations to be done, which reviews their stoichiometry, and they encounter very little chemistry which calls for prerequisites that they have not had. While qualitative analysis should properly precede quantitative analysis in formal courses of study there is really very little use made of qualitative results in simple volumetric work such as acidimetry and alkalimetry, oxidation and reduction titrations and iodimetry. Such reactions as the pupils are unfamiliar with can be studied as need arises and calculations can then be based upon them.

In conclusion, the author is still of the opinion that *there isn't any such thing*, although he may be like the old lady about whom the old gentleman said, misquoting Scripture, "As a woman thinketh so is she and don't you forget it."

Digitized by Google

THE ROLE OF LABORATORY WORK IN GENERAL SCIENCE AND THE TEACHER TRAINING IT INVOLVES.[1]

By Herbert Brownell, B. S.,

Professor of Science in Secondary Education, Teachers College, University of Nebraska, Lincoln, Nebraska.

Ladies and Gentlemen of the General Science Section:—No apology is necessary, so I am assured, for appearing before you *with a paper to be read.* Nevertheless, it may be well to "explain" that by so doing you can rest assured that in due time—say in thirty or thirty-five minutes—I will at least have reached the end of my paper. So complex are the relationships in any consideration of what characterizes a laboratory basis for the teaching of general science, and so difficult is a discussion of the problem of providing suitably trained teachers to make this work a success, that without the limitation of a manuscript the temptation to unduly prolong the discussion might prove irresistible.

In the period of world upheaval from which we are so slowly emerging, the American public under stress of necessity has become familiar with many and diverse sorts of "substitutes." In the recent sugar shortage there was a near-rebellion in my family over the use of syrup on breakfast foods. Not one of us would allow that there is any substitute for cane sugar. In twenty-six years of training science teachers for secondary schools, I have been unable ever to find any satisfactory substitute for the laboratory in science teaching. The same is true, too, for my methods courses for teachers of general science, youngest of the high school science subjects.

We all have heard of the man who finally succeeded in getting his old horse to live without eating only to have the "critter" die on his hands. I am convinced that without laboratory work of an appropriate kind general science, too, will die! And unswerving as my advocacy has been for years of the claims of general science for a place in the curriculum of the high school, if it be a text subject only, and is to remain that, then in my opinion it deserves to die. In this connection let me say, however, that my notion of what is properly included under the term laboratory work in high school sciences, especially in such a subject as general science, may not be considered wholly orthodox by all science teachers.

---

[1]Given before the General Science Section of the Central Association of Science and Mathematics Teachers, Chicago, November 29, 1919.

Digitized by Google

You to whom I have the great pleasure of speaking today in this discussion of the teaching of general science *as a laboratory subject*, are able, by reason of your positions and standing in the educational world, to exert a powerful influence upon what eventually shall be the manner in which general science is taught. As I view the question of laboratory exercises in general science, it is not so much a matter of any set form of procedure, or of any specified list of exercises, as it is a question of the spirit and general educational purpose involved.

It has long been my belief that aid of a helpful sort is continued to my students during their first teaching experiences in their own schools through use by them in the different sciences of certain carefully prepared manuals as *Laboratory Lessons*. These contain matter supposedly suited to high school classes, especially those of the smaller high schools, and are so arranged that much of the instruction of the course as a whole centers in and can be grouped about simple inductive laboratory exercises. These exercises seek to provoke and direct the thought of pupils progressively toward the several teaching ends in view in every lesson. They are not exclusively experimental, but often consist of sets of prepared questions, of required drawings and descriptions, of various problems and other quantitative exercises. With increasing experience on the part of the teacher, he is expected in due time to become more and more independent of these aids, and able to select matter and organize a laboratory presentation of it in ways more or less original and suited to the instructor and to his teaching conditions. Because of this belief in the worth of laboratory manuals to teachers generally, and believing as I do that manuals are indispensable to those inexperienced in laboratory instruction in high school sciences, I beg your indulgence as I quote in substance only, and somewhat briefly, from an article which appeared in the June number of SCHOOL SCIENCE AND MATHEMATICS under the title, "The Laboratory Manual—Its Purpose and Contents":—

In visions of what in general shall characterize this best-of-all manuals, certain outstanding features have gradually taken shape.

In the first place, any such manual lends itself to a conception of the laboratory hour *as a study period.* During laboratory time under guidance of the instructor there is possible a methodical and sustained training of pupils day by day in ways of

Digitized by Google

acquiring knowledge which are characteristically scientific, and at the same time not exclusively experimental.

In the second place, before any experiments are worked by pupils, this manual provides that there shall be assembled through questioning, whatever knowledge the pupils possess of the topic under consideration, and that this knowledge be organized around the results of a certain small amount of experimental work *done by the teacher*. Obviously, these experiments must be simple, and so chosen that a scientific understanding is secured both of the old and of the newly acquired knowledge. The experiments are designed to arouse and sustain interest, provoke thought, and become centers of new groupings of knowledge. Whether such preliminary discussion requires one period or two, and whether or not it be completed during one day's session, is of far less importance than are the teaching values attained in the time spent in the discussion. To hurry the presentation of scientific fact and theory upon pupils mentally unprepared to receive it, and indifferent because of this unpreparedness, is to defeat the purpose which prompted the haste.

It is both the province and the opportunity of the instructor during this time of introductory discussion to guide it in such ways and to so enrich its content that time spent upon it *constitutes a teaching period of largest possibilities.*

To interpret simply and effectively the many unrelated experiences of pupils, the instructor must be prepared to contribute a large measure of additional information to the end that what is known by the pupils shall have scientific organization and significance. Each succeeding phase in the discussion of any problem then acquires its correct bearings and scientific relationships.

During the time spent in the laboratory in writing up the results of exercises worked out, and in answering questions raised in connection with these exercises, need arises for use by the pupils of texts and reference books in order to satisfy every desire for knowledge more definite and more complete. Here is the time of all times for a training in the right use of the text as a book of reference. There is great educational gain in thus stimulating and establishing that habitual attitude in pupils which leads them to discern clearly just what information is needed, and which directs them in the ways of acquiring this knowledge *at the very time when it is most serviceable to them.* Such training as this "carries over" from school days into all

Digitized by Google

the varied activities of later years. This combined use of books and experimental exercises in teaching secondary school science is far more productive than is their separate and more or less unrelated use.

Certain questions, too, are to be provided in this manual. These seek to anticipate difficulties likely to be experienced later in the text assignments, questions which necessitate a discriminating use of text and reference books in a search for information of a specific character. Such requirements lessen the time spent later by pupils as text preparation for "recitations," for "quizzes," and for "examinations," since some of the more extended discussions of the text thus have been disposed of.

In so far as there is a simple experimental basis for it, the manual fittingly appropriates to its introductory discussions portions, too, of the theories of science. There is little likelihood in any such procedure of a failure to leave for subsequent text discussions sufficient difficulties to tax fully both teacher and pupils.

It has been my desire in making as above these rather free quotations from the article in question to emphasize strongly a personal belief that the teaching of elementary science measures up to its possibilities only as its laboratory exercises *are correlating centers for all phases of the teaching process*. This belief amounts to a conviction—a conviction based upon many years of testing in my own work, and upon results known to have been wrought out in teaching done by others. Especially do these beliefs apply in the teaching of general science. As a science subject, taught without well defined and well sustained laboratory features, general science fails to function properly in public school education.

The laboratory manual should direct a teaching procedure in which instruction is combined with an experimental presentation of the topic studied. These features must be so inextricably interwoven that teachers inexperienced and ill-prepared cannot go far astray in their teaching, and then only after much the same degree of difficulty experienced by the Senators at Washington in disentangling the League Covenant from the Treaty of Peace.

Do not misunderstand me! You to whom I am speaking may be wholly independent of any need to follow laboratory manuals as published unless it be as time savers in laboratory adminis-

Digitized by Google

tration. Trained science teachers of long experience in large city systems can well be left to choose and combine and use successfully material of their own for science courses. Their laboratory problems are of a different nature. But let it not be that we who are earnest advocates of the worth and excellence of general science in high schools be blind to the fact that the future of this subject as an integral part of public school courses is largely in the hands of high school teachers lacking your experience and fitness for teaching—teachers to whom the role of effective laboratory work in elementary science teaching is yet a matter of discussion rather than of performance. Relatively very few high schools employ special teachers for the different science subjects. In many of the smaller high schools the untrained unprepared "science teacher" faces teaching conditions suitably characterized as "impossible."

We are not altogether hopeless of the coming of a time when general science shall be taught by those only who are especially prepared to do it, and who have the all-round teaching skill so necessary to meet successfully its teaching difficulties. But we have to confess that to our certain knowledge there are yet many things in connection with science in the public schools over which we as science teachers lack control, not least of which is power to say *who shall not teach science in high schools.* As a matter vital to the future of general science, its advocates can insist that its teaching on any basis other than laboratory exercises is to invite failure generally with promise of success only when in the hands of the relatively few exceptionally capable teachers, those likely to succeed in the teaching of any subject. The instruction given should follow such a procedure that the average teacher in the smaller high schools need not make a failure of general science, but rather make a great success of it. There is need of a manual calculated to serve general educational ends as well as the special purposes of a scientific presentation of topics included in a course in general science. Publishers will, I believe, be glad to provide such manuals when any considerable demand for them is voiced. The problem under discussion is made doubly difficult by the fact that in the small high schools there is an endless round of changes in the teaching force, and teaching efficiency *through experience* is little in evidence.

For seven years now I have been giving in the Teachers College of the University of Nebraska "methods courses" in general science, repeated the first and second semesters and in summer

Digitized by Google

session. These classes of prospective teachers have averaged twelve or more, but there is no sufficient reason for believing that these students with this limited special preparation have all taught general science. It is reasonably certain that few of them have continued as "science teachers" through many years. The School Directory issued by the State Superintendent of Nebraska for the year 1918-19 names 380 high schools employing four or more teachers. Of these 250, or 65 per cent of them, reported to the office of the Inspector of Accredited High Schools courses given in general science. This means that *in seven years' time* I have had about as many students in my two hours' methods course in general science (241) as there are schools in which the subject is being taught. Now I do not flatter myself that any school board has waited seven years in order to get one of these teachers. The total number per year of prospective teachers of general science from all the teacher training agencies of the state is pitifully inadequate to meet the needs of the public school system.

Speaking in general terms, and without data to verify the statement, the common procedure in general science as taught in high schools is to require pupils "to recite" upon text assignments, with laboratory work lacking entirely, or merely incidental and spasmodic in character. It seems safe to assume from knowledge at hand that a large majority of those teaching general science in the smaller high schools have neither had any sufficient preparation for this very difficult teaching, nor do they intend to continue teaching the subject and thus become proficient through practice. In many cases, so I have reason to know, general science is assigned to a teacher in spite of her protests of unfitness to give instruction in it, and of an unwillingness to undertake it. The subjects of the curriculum are "divided up" among the members of the teaching force, and the person making least protest gets general science. I have more than a suspicion that similar conditions may be found elsewhere than in Nebraska, possibly in the communities and states from which some of you come. Wherever such conditions are found, there is warrant for a note of alarm over the future of general science. There may come a time when advocates of this subject will be called upon to show cause why it shall not be dropped from the curriculum of the high school owing to lack in educational values attained. The introduction of general science into the high schools of the country has been so rapid as to be a joy to its

Digitized by Google

advocates. It may be it would have been as well if its introduction had been slower. If reasonably well taught, its permanence in high school courses is assured. But continued lack of any laboratory basis for instruction in it, and lack of teachers sufficiently well prepared to give this instruction, may even yet turn the tide against it.

It can be taken for granted that teaching success in the sciences as in other high school subjects involves an ability on the part of the teacher to secure well sustained efforts on the part of pupils in satisfying the normal human desire to learn *whatever is worth knowing*. The greatest of all teaching difficulties encountered in the elementary aspects of the sciences does not inhere in the subject matter, but lies in the "human element" involved in the teaching process—lies in the boys and girls under instruction who all too often are indifferent and sometimes antagonistic to a teacher's efforts. Advocates of general science have won for the subject a permanent place in the high school curriculum *on the ground that it is based upon broadly educational rather than strictly scientific lines*. While inevitably it is introductory to later courses in the differentiated sciences of the high school, such is not its chief purpose. Whatever is of largest educational advantage to the boys and girls under instruction, providing it is germane to discussions of the phenomena of natural science, dominates all other considerations. The selection of matter, and the manner of its presentation, should take into account first and all the time the intellectual fitness of pupils as the men and women of tomorrow. Here, too, is ample warrant for an enrichment of its discussions by consideration of the applications of science to social and economic welfare. And we take occasion right here to express the hope that the time may never come when this course of the secondary school curriculum shall lose the flexibility it now has, and teachers their freedom to adjust its matter and method to fit widely varied teaching conditions.

Any discussion of our subject restricted to the two items (1) a supply of suitably prepared teachers for general science, and (2) their presentation of the subject upon a laboratory basis, is incomplete. For it is shortsighted ever to expect in the smaller high schools of the country teachers trained for general science alone. Nor would this be desirable. While in teachers colleges and in normal schools there properly is a "special methods" course in general science, the preparation of teachers for this

Digitized by Google

subject should by all means include at least enough of the elementary phases of other high school sciences so that in the smaller high schools the teacher of general science is the "science" teacher in the corps of instructors. Preparation for this teaching of "high school science" should be extensive rather than intensive, making any suitable preparation of science teachers for small high schools especially difficult.

In the aggregate a large number of young men and young women who have been in my classes have later taught science in the high schools of Nebraska, and in adjoining states. The teaching conditions encountered by them in the various schools, and the various factors personal and otherwise likely to determine their success or failure, have been matter of inquiry, of observation and of personal concern. The needs of the smaller high schools for closely correlated science courses effectively taught, and the apitude manifested by those anxious to qualify for this teaching, have ever furnished me an incentive for sustained efforts through many years in seeking a greater teaching efficiency in the high school sciences.

During these years of my teacher training experience, profound changes have occurred in the character of science teaching in the schools of Nebraska as elsewhere the country over. There has been great increase in the number of high schools, in the number of science teachers needed in them, in the extent of laboratory courses, and in the equipment for such courses[2]. The aims of high school science teaching have undergone great changes, too. No longer is one who has "specialized" in some one of the sciences, *e. g.*, in chemistry or in physics, considered as sufficiently fitted thereby to meet the varied demands made upon him *as the science teacher in a small high school.* Demands made by school boards often amount to an unqualified insistence for teachers who possess general knowledge in all the fields of science, a knowledge which though elementary is definite, unified rather than differentiated, and closely related to the social and economic life interests of the pupils taught. The demand is for ability to aid high school boys and girls to acquire such understanding of the phenomena of their natural environment as develops in them an habitual attitude characteristically scientific.

Whatever money can buy in the way of furnishings, books, etc., is available in these days in almost every community for use by science teachers of proved competency. But so far as the

[2] "The High School Situation": Woodhull, in *General Science Quarterly* of March, 1917.

Digitized by Google

smaller high schools are concerned, teachers of high ideals and large aptitude, and who at the same time are masters of the purposes and procedure of laboratory science suited to beginners, would seem lamentably scarce in our American public schools. This in no sense warrants any relaxation in effort for meeting the needs of these schools in every way possible, nor does it justify a return to the discarded plan of attempting to meet these needs by certification of those who have specialized in some one science, and then have added to this academic preparation a few "courses in education." Bitter educational experience has taught the futility of this solution of the problem of providing science teachers for the smaller high schools.

Throughout this discussion which now must be drawn rapidly to a close, I have purposely avoided consideration of the peculiar problems confronting teachers of general science in the large high schools where sections of maximum enrollment occupy all the time and resources of special teachers. Despite the amazing total of pupils in the large high schools of the country, and the necessary modifications in procedure to handle the crowded classes in general science in these schools, there is at least some large degree of permanency in the teaching force of such schools. But failure here to teach general science upon a laboratory basis, whether of the standard type of such special sciences as physics and botany and chemistry, or the greatly modified and simple procedure suggested above in connection with the characterization of laboratory manuals, invites the same condemnation and rejection of general science in the curriculum of the large high school as in the smaller one. Whether or not experiments are performed exclusively by the instructor as each topic is taken up in turn, and what ever may be the combination of experimental work, discussion, study, and written efforts, it is possible for teachers of general science in large high schools as in small to develop, to direct, and to habituate pupils to the spirit and procedure of laboratory sciences. The worth of this training easily transcends the informational values of the course, however great these may be.

We who are especially concerned with the future of general science can well afford to unify our aims in our various fields of endeavor, though our procedure in attaining them may have little in common. Diversity in method is wholly compatible with unity in aim, and nowhere in school work more so than in general science.

Digitized by Google

And now in closing may I say that I am ever impressed with the sanity of a demand that he who theorizes in education, and who undertakes to formulate its principles or to present for consideration any philosophy of education, may very justly be required at the same time to specify by what course of action this theoretical shall become practical, establishing his right to a hearing by reason of evidence of success in an application of his beliefs. That architect alone is great whose visions take form in drawings, plans and specifications, and eventually in enduring structures of stone and steel. My belief based on experience is that the views presented in connection with this discussion of the "Role of the Laboratory in Teaching General Science" will stand the test of application. Too much of enduring value has been hard won for general science in the field of public education to warrant risking loss of what has been won. Can we not unite in insisting that in all general science teaching there shall be the spirit, the procedure, and the values of experimental science?

FEDERAL AID TO SOLDIERS.

In almost every community in the United States there is a discharged soldier, sailor, marine, or war nurse, suffering from some injury or ailment which dates back to service with the fighting forces.

Often this injury or ailment has made it hard or impossible for them to fit in where they did formerly. They are handicapped and need help; not charity, but mental and physical reconstruction. In many cases such people unfortunately keep their troubles to themselves. They are reluctant to seek aid or advice, for fear their friends might consider them weak. Possibly you know such a person.

If you do, encourage him to take his troubles to the Government. The War Risk Insurance Bureau and the United States Public Health Service are especially anxious to get in touch with such individuals. The Public Health Service has set up a chain of reconstruction bases throughout the country for beneficiaries of the War Risk Bureau. These are not army hospitals, nor is there army discipline in connection with them, but rather a system of hospitals similar to the general hospital in large cities except that the treatment is free and goes much further than in the ordinary hospital.

Recreation, vocational training, and wholesome entertainment are combined with treatment. While men are being bodily rebuilt they have the opportunity of learning some useful occupation, or pursuing academic studies. They are taught not only to find themselves, but to better their condition. The environment is as homelike as it is possible to make it.

A great many men who went into the army have developed tuberculosis and other diseases requiring special treatment. The Public Health Service has separate hospitals and sanatoriums for these patients, where they may get the best treatment known to medical science.

A large number of soldiers are not yet aware that the Government offers them free treatment. Please tell them.

Digitized by Google

POSSIBILITIES OF HOME WORK IN GENERAL SCIENCE.[1]

By Prof. G. A. Bowden,
University School, Cincinnati, Ohio.

A few months ago while conversing with a teacher of English in a large city high school, I learned that she had directed her pupils to write a description of the domestic house cat from first-hand information gained from the living subject. The following day the students apologized for not having prepared the descriptive theme according to the instructions given, because, after due search and diligent inquiry had been made, they had failed to locate this species of animal. The intent of this teacher of English was grand, life descriptions must be made from living subjects, but she failed to get such descriptions from her pupils for the very reason that she is living behind the time and advancement of our modern age. She should have known that in all well regulated city homes the cat has been strictly replaced by the simple spring mouse trap in much the same manner that the horse has been driven from our city streets by the automobile and auto truck. Furthermore she should have known that the pet of her maiden youth has become very unpopular as a carrier of disease, an element in the high cost of living, and in the teachings of Audubon societies, and for these reasons her pet in memory has been outlawed and consequently not commonly found in a well established and up-to-date community.

But what do you actually think of a teacher of general science who taught the construction and operation of a hot air furnace in the space of fifteen minutes, and who on the following day sprung a twenty minute quiz on his pupils to test their understanding of this heating and ventilating device? The teacher of English who desired a life description of the recently ancient cat is an artist and an up-to-the-minute teacher compared with him. Her pupils did at least discover the scarcity of cats. What did his discover? Did they really discover that a hot air furnace has an actual existence and a relationship in and with a fairly modern home? She had at least an actual project in mind and had sent her pupils forth on a happy quest to search and to learn from first-hand experiences, but his went forth from a room actually ventilated with confusions and abstractions to return the following day to a bondage of classroom despotism

[1]Read before the General Science Section of the Central Association of Science and Mathematics Teachers at Lake View High School, Chicago, November 29, 1919.

Digitized by Google

to be examined on a superficial nothingness which, happily, was no part of them. I know that you are thinking that these illustrations are far- and over-drawn; perhaps they are, but they illustrate well the purpose of this paper.

The possibilities of home work during a course in general science depends wholly upon the attitude of the teacher who is handling the subject. If the course is limited to the mere dimensions of the classroom or laboratory of the particular building in which the teacher is offering instruction, there are no possibilities for home work in his general science course. On the other hand if the teacher realizes that of all the subjects offered today in our courses of secondary education that general science is the one subject that deals with the translation of the physical elements that make up the home and community life of man he will find that there is abundant opportunity for a great deal of delightful and inspirational teaching which will send his pupils back into the home and community eager to experience and give expression to the elements and factors of their very lives that existed heretofore deep in the substratum of their consciousness. Failing to receive this directional teaching a child's subconscious mind becomes a veritable grave-yard of ideas and thoughts that might have found an expression in a living consciousness instead of passing into an accepted oblivion in which there is no analysis into "the why of things."

To insure the success of this kind of work in the classroom and in the home the teacher must necessarily survey the "stock in store" of the average individual pupil that confronts him. He must acquaint himself with the amount and kind of nature study work, geography, physiology, elementary agriculture, manual training, and other elementary sciences and arts that have been taught to the child while climbing up through the grades. For today a lot of wholesome work is being done in these pre-elementary sciences of the grades, and this work bears much the same relationship to the general science course that the sciences of the high school period bear to the early sciences of our universities and colleges. He must study the community in which the child has been reared and catalogue, so to speak, the experiences and daily phenomena with which the child is already acquainted in a more or less superficial way. Having made these surveys and catalogues of the elements and factors that make up "the stock in store" of his pupil, the teacher must determine upon a course of projects which will lead his pupil

Digitized by Google

into "the heart of things," a course of projects that are in themselves related and capable of an easy classification; a course of projects that leads the child's mind more or less consciously to see the relationship of things and events from the standpoint of cause and effect; a course of projects that aims to develop an attitude of observation that leads to conclusion of fact and principle.

In an endeavor to embody this spirit and mode of presentation in our general science course in the University School at Cincinnati we have built the course about the following series of projects:

1. Lighting the home.
2. Heating the home.
3. Weather and climatic conditions about the home.
4. Building the home.
5. Clothing and feeding the individual of the home.
6. Communicating with the home.
7. The home and its relationship to the world's work.
8. Life and self improvement.

As you at once observe, we have emphasized the home element throughout the series of projects. The common criticism is that such a selection of projects narrows the field of general science, but such is not the case, and quite the contrary is true. Here, at least, we have no series of subjects on certain portions of chemistry, physics, biology, astronomy, earth science, physical geography, and physiology which have no relationship other than the buckram that binds the text in which such an arrangement is presented.

What does the first project, lighting the home, suggest to you? In order to develop this project we are led to take up the following sub-projects which present themselves at once in a natural sequence: the discovery of fire and with it the primitive uses of heat and light; various primitive lighting methods such as the firebrands and the vessels of burning oil with and without wicks; the development of the candle; kerosene and the kerosene lamp; gasoline and the gasoline lamp and its need of a mantle; illuminating gas and gas lighting with its two types of lamp, jet and mantle; electric energy and the development of the filament and arc lamps; natural and artificial lighting; and direct and indirect lighting systems. These sub-projects, of course, suggest subsidiary projects and problems to which attention is necessarily called during the process of its development, and thus we see that each project becomes automatically a center of logical organization.

Digitized by Google

The project method of attack makes home work a possibility for the very reason that it incites the pupil to action rather than to inaction and reaction. Let us consider the project of lighting our home and here discuss a mode of attack or presentation for the first sub-project, the discovery of fire and its primitive uses. The actual discussion between teacher and pupil arises from the following considerations:

Was primitive man ever without fire?
How did he at first obtain fire?
Did he later learn to produce fire?
What were the methods of producing fire?
Did the American Indian use any of these methods for the production of fire?
How did the Pilgrim start his fires?
Have you ever started a fire by any of these methods?
Will you try and see if you can succeed?
Will you bring to class the articles and materials which you used in trying to produce fire whether you succeeded or whether you failed?
What effect did the discovery of fire have upon the life of primitive man?
Did he light his home?
Did he have a portable light?
Will you prepare some firebrands and bring to the class?
Have you ever seen a picture of a Greek or a Roman lamp?
Describe its shape.
Can you name the materials of which it was made?
Name the oils used in these Greek or Roman lamps.
Why did they use a wick in these lamps?
What materials were used in manufacturing the wick?
Will you make such a lamp out of modeling clay and bring it to class ready for use?

Here we have the pupil and teacher on a common ground but viewing the situation from different points of view; the pupil supplying the bits of information that he has already picked up, and the teacher adding information that will direct the pupil into channels that furnish a more definite and clarifying understanding of the question in hand.

Of course some assignments must be made. I have found the boys ready and willing to try out the methods of producing fire, while the girls will take the easier task of producing the firebrands and clay models of the Greek and Roman lamps. And also as a matter of aid we have the modeling clay on hand ready for distribution. And right here let it be said that the teacher is to be more than reasonable in his demands for this kind of home study and home work. Never attempt or demand the impossible by asking the pupil to work with materials or instruments which he has not readily at hand. For example, should the teacher ask the pupil to make a study of temperatures in the various parts of the home refrigerator, this task is at once impossible for those pupils who have no thermometers. Have

Digitized by Google

your thermometers ready packed in strong cases ready to loan for such home work. The pupil borrows valuable books from the library for home work. Why not some of the hallowed things of the laboratory? Do you not think that he will take a pride in explaining and setting forth his knowledge of the thing in hand to his father, his mother, or immediate relatives and friends? Do you not think that his bit of private intimacy with the thermometer, electric bell, or whatever it may be, will not result in the best kind of self improvement and soundness of understanding?

Now what are we to do the next day when the pupils present themselves with firebrands, fire making apparatus, and Greek and Roman lamps? The first matter of importance is that each pupil be given an opportunity to exhibit before the class the apparatus or materials with which he has worked, giving in his own manner the reason for selecting the materials and explaining the method of successful operation. If the pupil has failed to get the results for which he has worked, he is to explain the cause of failure from his point of view. This attitude of mind that discovers the reasons for failure is of the greatest importance and is one of the elements of mind training and character building that is to be emphasized throughout the course. After each pupil has reported his efforts comes the class demonstration. The successful fire makers are to come before the class and operate their various implements in a contest for the production of fire. The remainder of the class are being acquainted with the various primitive methods and the relative merits of each. Of course these primitive tools are in inexperienced hands, and the performance of the operation may not be that of the expert, but the performing individual and the observing individual are receiving better concepts than teacher or book can ever impart. Next the firebrands and the Greek and Roman lamps are put into operation by the pupils who brought them, and various points of comparison and contrast are pointed out and emphasized. After the pupils have made their recitations and demonstrations, it becomes the teacher's part to develop those parts of the lesson which thus far have not been given full and proper expression by the pupil. In this lesson it is quite certain that the pupil will tell you that he rubbed the sticks together to produce fire or heat; it is the teacher's function to develop terms, definitions, and generalizations closely allied with this very act, such as *"friction," "friction results in heat," "kindling*

Digitized by Google

temperature"; the girl who brought in the Roman lamp will surely tell you that the wick is for the purpose of conducting or leading the oil up to the flame; it is now the teacher's mission to develop the term "*capillary attraction.*" And so it goes throughout the entire course of projects, the pupil gathering together the concrete expressions, seeking for causes and effects in so far as he is able, and then the teacher stepping in as an assistant to help with the defining, abstracting and generalizing of the question under consideration.

As man progressed in his civilization his habits became more and more complicated, and since the projects enumerated above are taken somewhat in the order of their historical development, we shall find that the presentation of the project becomes degree by degree more and more complicated. It is the business of the general science teacher to design and arrange his projects in such a manner as to direct the pupil through this labyrinth of human problems. Now it would not do to develop all the projects in exactly the same style and manner as we did those for the production of fire, firebrands and Greek and Roman lamps. The plan of attack and the program suggesting the order of action must be varied with each type of project. These changes and variation of method in the handling of the project plan are imperative, if the teacher desires to develop a pupil who at the conclusion of the course shall be prepared and equipped with a mental attitude of doing things and reasoning out the solution of problems for himself.

Consequently, when we take up the candle as our next project in the lighting of the home, we vary our method of attack and assignment for the home work. Here Michael Faraday in his *Chemical History of a Candle* has fully developed for us the best possible method of presentation, and the teacher can do no better than to follow step by step the methods therein suggested and assign as library or home reading definite portions of this wonderful classic. Instruct the class to make at home a dip candle as suggested by Faraday, using paraffin in the place of tallow. Tell them to experiment with the candle in the same manner as Faraday did and to observe all the phenomena that he calls to their attention. (Here it is necessary to give to each pupil an ounce of paraffin, a short piece of glass tubing with fire polished ends, and a piece of fresh lime with directions for making and using lime water.) You teachers who have never read Michael Faraday's *Chemical History of the Candle* are not

Digitized by Google

in position to grasp the importance of this kind of assignment. Michael Faraday lived in the days of candle lighting, in the days when the candle was a household necessity, and therefore was able to write from a standpoint of actuality that fairly radiates, and the teacher of sciences who fails or neglects to call these spirits of the past to aid him in presenting his subject fails in the development of refined tastes, or powers of appreciation, and mental growth.

The pupils are again before us after spending an afternoon or evening with Michael Faraday and his candle. Again as before each pupil is called upon to relate his particular experiences, observations and conclusions. As the conference hour proceeds each succeeding pupil should be urged to present the matter with greater care of order and detail. The teacher who appreciates the value of scientific exposition, though expressed in a narrative manner by the pupil, will find that the majority of his pupils have acquired through their own effort a conscious order of things and facts. This is the kind of training desired, habits of mental activity that are orderly—orderly without too much effort that labors for order. True some of his pupils will show a chaotic condition of mental processes while rendering the recital of the observations and interpretations of their personal experiences, and so here again it is the mission of the science teacher, like a Faraday, to point the way with patient indulgence. Then it is the teacher's business to give suggestion or question. The question or suggestion must drive straight to the heart of the subject under consideration. For the above project we may suggest or question as follows:

Did Michael Faraday talk about capillary attraction?
Did Michael Faraday give other illustrations of capillary attraction?
Did Michael Faraday say that a candle flame needed fresh air?
How did Michael Faraday prove that a candle needed constantly a supply of fresh air?
What part of the air did Michael Faraday say was taken by the burning candle?

This kind of question calls for the answer set forth by Faraday, and so the pupil will set up reflective processes endeavoring to remember what Faraday actually said. A better way of presenting the suggestive question is to direct it towards the pupil's personal experiences gained working out the project. Such questions are as follows:

Did you discover capillary attraction at work in the burning candle?
Or better,

Digitized by Google

Why is a wick necessary in a candle?
Will any kind of a thread or string serve as a wick?
How did you prove for yourself that a burning candle needs fresh air?
What part of the air is necessary to a burning candle?
What new gases or products are delivered to the air in the place of oxygen?
Are man and animal dependent upon the air as is the candle?

On the other hand, the teacher may not find it at all necessary to ask any questions; it may be the reverse, the pupil asking, the teacher answering. The best condition that can prevail is when teacher and pupils "gather together in the classroom for class conference" for the purpose of comparing their individual experiences and formulating a conclusion or solution for the problem in hand. No home work should ever be attempted that cannot be followed in class conference or in conference with the teacher, for the average pupil's efforts on home work are in direct proportion to the amount of attention given to it.

Time and space limits prevent the outlining of other projects and the pointing out of the sub-projects in each case for home work. However, let it be stated at this time that the child who goes into his home with proper oral directions or with easy written instructions of procedure for the study of the actual thing as it actually operates in his home, in his neighbor's home, or in the community will have a better understanding of the construction and working relationship of the parts than the pupil who is merely class taught from drawings whether they be on blackboards or in texts. The drawings that he makes of the system that he finds actually operating will be symbols of living concreteness compared with those of the student who endeavors to get his from diagrams alone. When each pupil has worked out a system for himself, then the drawings and designs of similar systems may be called to his attention and compared with those that he has made. In this manner heretofore meaningless diagrams and arrangements of things into systems expresses ideas and thoughts to him in much the same way that words, sentences and paragraphs of his story book express to his mind mental pictures of scenes and scenery. No problem in the textbook or from the teacher will have the same effect as that which the pupil makes for himself while reading gas or electric meters in the attempt to calculate the family expense in this respect for a day or a week. When this is done, the problem of the textbook offers itself as a wholesome challenge.

Throughout the course there is the desire on the part of most of the pupils to make or repair something in the home. In the

Digitized by Google

University-School we give the general science course to the pupils of the eighth grade and after they have worked through a few of the projects, they are continually seeking individual conferences concerning some piece of apparatus that has been suggested to them. One wants to make or repair a thermostat; another wants to rebuild or rewind a toy motor or dynamo or wireless set; still another desires complete details and advice on materials and details for the construction of a fireless cooker; another wants to know how to arrange lamps, wires and switches that will turn on the lights at the house and off at the garage; and so it goes throughout the course. We seize on these opportunities and make capital of them, for we make that problem that pupil's project, and when the right time in the course presents itself, we invite that pupil to present his problem and his solution of it to his fellow pupils, not merely to discuss and tell about the project but to demonstrate it.

Another agent that aids the teacher of general science to carry the problems of the course into the home is the portable projecting lantern, the lantern slide picture and the post card projector. The writer makes use of what he calls "the pupil's lecture." The teacher or pupil selects a group of slides or post cards bearing upon some future topic that will come up in the course. The pupil takes the slides or cards along with the lantern to his home. That night that family will have an illustrated lecture with the pupil acting as the lecturer. The help that he receives from the parent or friend to see deeper into the picture's meaning, or the criticism that he receives, depends, of course, upon the degree of family interest, and the ability of the members of the family to aid and criticize. Whatever the family attitude or ability be, the pupil has benefited from his recital and interpretation of the pictures to the family circle. The pupil may or may not be given a written description concerning the pictures that are loaned to him. It depends largely upon the subject matter. If the series of slides are on coal mining and the pupil is unacquainted with the machinery and terms of this industry, a written description must, from the nature of the case, accompany the slides. However, if the group of slides are on the handling and care of dairy products, it is better that he should carry his slides to the creamery and milk stations, and there find the machinery and tools and men in operation, and while there discover the worth and meaning of each picture and thus prepare his "pupil-lecture." The "pupil-lecture" thus

Digitized by Google

prepared is given in the class conference when the related project is under consideration. When properly stimulated and directed it is difficult to overrate the value and immediate effect of this kind of work on the part of the pupils.

Again, in every class, individuals will be found who possess cameras and who are doing their developing and printing. These individuals can be taught in one short lesson the details of lantern slide printing and binding. When this is done the teacher of general science has a resource upon which he may draw whenever occasion may arise. For example, long before we take up the project of "building our homes," one or more pupils are asked to locate homes in the process of construction and are instructed to make a set of pictures starting with the excavation for the basement and ending with the completed home. Interiors as well as exteriors are taken, and a full set of notes kept of observations made at the taking of each picture. These notes record the different classes of working men and the different kinds of labor that each is performing at the several stages in the development of the house; the various materials and their uses; the installation of the many systems; gas, electric, water, sewage, heating, ventilating and vacuum cleaning; and any other items that the pupil considers of interest in the development of his problem. In this sort of self activity the pupil must do his own discriminating, his own comparing and contrasting; he must weigh and evaluate for himself; he must assign values.

Since this paper has placed emphasis on the possibilities of home work, the writer would not have you think that all the work of the course in general science is to be done at home; that all the projects are home projects. By the very nature of the case some problems are confined in their demonstration at least to the laboratory and classroom. Furthermore the writer would not have you think that his methods of assigning a home problem for home study are the only methods of attack; he offers them to you as the best methods from his own experience. The writer's plea is that there be less empirical presentations, less abstraction and generalization concerning things and facts outside of the pupil's observation and experience; a plea for the most effective methods of science teaching since the days of Huxley, namely a method of teaching by projects. Once we have established such conditions, the attempts of teachers of general science to translate to pupils of tender age the principles of life as exemplified in the home and community will have become a possibility.

Digitized by Google

RESEARCH IN PHYSICS.

Conducted by Homer L. Dodge.

University of Oklahoma, Representing the American Physical Society.

It is the object of this department to present to teachers of physics the results of recent research. In so far as is possible, the articles and items will be non-technical, and it is hoped that they will furnish material which will be of value in the classroom. Suggestions and contributions should be sent to Homer L. Dodge, Department of Physics, University of Oklahoma, Norman, Oklahoma.

THE COOLIDGE (THERMIONIC) X-RAY TUBE.

This is the fourth of a series of articles on thermionic tubes.[1] Those who have read the former articles will recall that the thermionic valve and amplifier operate at reduced pressures and do not depend for their action upon ionization by collision. The Tungar rectifier, on the other hand, is able to carry its heavy currents only through the agency of positive ions produced by the impact of the electrons on the molecules of the gas present in the tube. X-ray tubes, while different from the above tubes in essential particulars, are in many respects similar. The ordinary tube depends upon ionization of gas, as does the Tungar rectifier (the Tungar rectifier could carry a small current through the agency of the thermions produced by the hot filament and is, in this respect, similar to the Coolidge tube), while the Coolidge tube is more like the thermionic valve. Mechanically, all of these devices are nothing but glass bulbs fitted with two or three electrodes. Yet, in spite of their apparent simplicity, they are highly specialized devices and, in their present forms, are the result of the skillful application of the discoveries of modern physics.

How cleverly the needs of the X-ray worker have been met by the use of thermions and the proper designing of tubes will be made apparent if the newer tube is compared with the older type, the one commonly found in the high school laboratory and, until recently, in the physician's and dentist's office.

The ordinary X-ray tube consists of a glass bulb with an aluminum cathode at one end, an aluminum anode at or near the other end, and a platinum-faced anti-cathode extending to the center of the bulb, with the face set at forty-five degrees to the axis of the tube. While in use the anode and anti-cathode are electrically connected. An appreciable amount of gas is

[1] "The Thermionic Valve," January, 1919; "A Thermionic Rectifier for Large Currents," March, 1919; "The Thermionic Amplifier," May, 1919.

Digitized by Google

always left in the tube, the pressure ranging from perhaps 0.001 to 0.010 mm. of mercury.

Although the number of ions present in this residual gas is normally very small, there are enough of them to produce further rapid ionization of the gas when a high potential is applied to the terminals of the tube. The effect is to accelerate the original ions and cause them to produce many more ions as they collide with the gas molecules. The electric field also serves to direct the positive ions toward the cathode which they bombard and cause to emit cathode particles (also called cathode rays). The field impels these cathode particles toward the anti-cathode. When they collide with this, their velocity is suddenly changed and X-rays are generated.

The penetrating power and "hardness" of the X-rays depend upon the velocity of the cathode particles which, in turn, depends upon the difference in potential of the electrodes. A "hard" tube is one that requires a high difference of potential to produce a discharge, the necessary potential increasing as the pressure is lowered.

In order that X-ray photographs shall be sharp, and often for other reasons, it is desirable that the rays originate over a very small area. This result is obtained by focusing the cathode particles upon the anti-cathode. Since cathode particles tend to leave the cathode at right angles to its surface, it is possible to shape the cathode to the right curvature to cause the proper degree of focusing. The focal distance is always several times the radius of curvature of the cathode, caused by the tendency of the similarly charged electrons to separate through mutual repulsion.

Since ordinary X-ray tubes depend upon ionization by collision, it is evident that any variation in the amount and pressure of the gas affects their characteristics. When first used they become "soft" as a result of evolution of gas from the electrodes. With further use they become harder and the gas is driven into the glass walls where it remains, entrapped by physical or chemical action or both. In the meantime they exhibit all sorts of disagreeable characteristics due to a large variety of causes such as static charges on the glass, etc. The absence of satisfactory scientific control is evidenced by the fact that it is good practice to "rest" tubes when they get in a "cranky" condition. Other difficulties met with in the ordinary tube are wandering of the focal spot, melting of the cathode, and blackening of the bulb,

Digitized by Google

caused by disintegration and evaporation of the electrodes.

Dr. W. D. Coolidge of the General Electric Company Research Laboratory at Schenectady made an extensive study of the ordinary type of tube and decided that many of the difficulties would be removed if the anti-cathode were made of a massive piece of wrought tungsten (melting point 3400° C.) and the tube freed from gas, in which case the electrons would have to be supplied in some other way than by bombardment of the cathode by positive ions. As a matter of fact, Dr. Coolidge succeeded in developing a tube free from practically all the limitations of the ordinary type.

The cathode consists of a tungsten filament in the shape of a flat, closely wound spiral, heated by a storage battery well insulated from the ground. The filament is surrounded by an electrically conducting cylinder which is connected either to the filament or to an external source of current by means of which its potential may be brought to any desired value with respect to the heated cathode. The cylinder assists in so shaping the electric field in the vicinity of the cathode that the desired degree of focusing of the cathode-ray stream upon the target shall result. The anti-cathode, or target, which also serves as an anode, consists of a single piece of wrought tungsten, weighing perhaps 100 grams. The bulb is about 18 cm. in diameter. The pressure, instead of being, as in the ordinary tube, a few microns, is as low as it is possible to make it, that is, not more than a few hundredths of a micron. Such a vacuum in the ordinary tube would require over 100,000 volts for the production of any current.

The action of the tube is remarkably simple. The hot filament emits thermions at a rate depending upon its temperature. Under the influence of the powerful electric field between the cathode and anti-cathode or anode the thermions are projected at enormous velocities against the anti-cathode in the form of a pencil of cathode particles which, on impact, produce X-rays. Accordingly, the intensity of the discharge current and therefore the quantity of X-rays is accurately controlled through the adjustment of the storage battery current flowing in the filament, while the hardness (frequency) of the X-rays, which depends upon the speed of the cathode particles, is determined by the voltage applied to the tube. Coolidge tubes have an enormous X-ray output and may be operated continuously without showing any appreciable change in characteristics.

Digitized by Google

In fact tubes have been run for hours while consuming several kilowatts of electrical energy.

Two characteristics of the tube serve to make it especially valuable in the taking of X-ray photographs or shadowgraphs, namely, the fact that the focal spot on the anti-cathode does not wander and that the glass does not fluoresce when the tube is operated properly. This latter fact is an indication that there is no bombardment of the glass by secondary cathode particles sent out from the target which would, of course, on impact with the glass give rise to X-rays. The sharpness of any shadow depends upon the smallness of the source. It is, therefore, desirable in an X-ray bulb that the focal spot be the only source of the rays and that this source remain stationery.

In the ordinary X-ray tube, in the case of a platinum target, it has been found that there are about three-fourths as many electrons leaving the target, and going to the glass as secondary cathode particles, as there are bombarding it in the form of primary cathode particles. This elimination of secondary cathode particle bombardment prevents the production of a large part of the useless and disturbing X-rays which emanate from the glass of an ordinary tube. The absence of bombardment of the glass appears to be based upon the fact that large numbers of positive ions present in the ordinary tube are here lacking. The inner surface of the glass becomes strongly negatively charged when the tube is first operated and, not being able to attract an appreciable number of positive ions, remains so. The presence of this negative charge upon the glass prevents further electrons either in the shape of primary or secondary cathode particles from going there.

The purpose of this brief article has been to call attention to the way in which the thermionic bulb has been adapted to the production of X-rays and the decided improvement over the ordinary cold cathode tube which results from such a small change. Anyone interested in the physics of the X-ray bulb should not fail to read Kaye's *X-Rays* (Longmans, Green and Co.). It is an authoritative and readable book.

Digitized by Google

ENGLISH EXPRESSION IN ITS RELATION TO TEACHING OF SCIENCE.

By R. R. SMITH,

School of Engineering of Milwaukee.

In a recent number of SCHOOL SCIENCE AND MATHEMATICS, I read with a great deal of interest an article relating to the failure of teachers of English to teach students to express themselves clearly on simple scientific subjects. I read it with interest for the reason that it was an attempt to state a condition of affairs as they exist; and it is absolutely essential that a condition be realized before there is the slightest possibility to find the cause of it and from the analysis of the cause work back to a remedy.

According to the article students cannot express themselves. Such seemed to me the conclusion at which the teacher of science arrived inductively after experimenting with many students. If I understood the article correctly he was rather just stating a deplorable condition and talking as if it were a state of affairs which could not be changed than seeking for a remedy or even trying to fasten the blame. He was even hesitating in his holding the teacher of English to account for the condition.

Of course we shall grant that it was kind of him to be charitable in his judgment of the teacher of English. It was kind of him to lead his reader to infer that the teacher of English was overburdened and for this reason could not be held responsible for getting results.

But, while we can admit that it was kind, we must at the same time affirm that it was far from scientific. If my gas pipes still leak after the plumber has been to my house, I immediately call him up and ask him to do his work again; he must do his work so well that the pipes will not leak. Such is the standard which we set up for every workman. He must produce results. Such is true also in the case of the professional man and the business man. Each must produce results. There is no reason why we teachers of English should ask to be judged by a different standard. To do so makes of us a group of parasites. As one member of the group I do not care to be judged in any other than the strictest scientific manner. I do not want to be placed in the group of parasites.

Our discussion immediately narrows itself down to this question: Can English expression be taught? Following this there

Digitized by Google

come two other questions which can be stated just as clearly; they are: What are the causes of the deplorable condition of affairs which was noted by the teacher of science quoted above? What are the remedies?

Briefly I shall set myself to the task of answering those questions in the remainder of this article. The first question is easily disposed of. English expression can be taught. It is being taught in newspaper offices, in business offices, in labor union meetings, and in all sorts of places where its teaching becomes at once an economic necessity. But only in rare cases is it being taught in our public schools. In short I think that we must first of all agree with our friend, the scientist, who was apologizing for us, that we do not succeed in getting our students to express themselves. In that case we have the case stated in plain terms. It remains but to reason back to the causes of this deplorable effect.

Why do not teachers of English get results?

In my own analysis of the question one reason has stood out paramount above all others. Teachers of English have tried and they are trying to teach English expression as a science and not as an art. I admit that this sounds trite; it is trite, but in so far as the teaching is concerned, when I have said that, I have said all there is to say. Look about you, and observe how people learn arts. How did you learn to walk? How did you learn to talk? How did you learn to swim, to ride a bicycle, to do any one of the hundreds of things that you do every day and do efficiently? You learned by watching another person do them and by trying to imitate him. It is true that you may have analyzed the reasons for doing certain things and that this analysis gave you an understanding of the principles which may have helped you in a further mastery of the technique of the proposition; but the learning of these principles at the time you learned to do any of the above-mentioned things hindered rather than helped you.

Just as you learned to do all the above-mentioned things by doing them after a certain model, so men and women who have learned to write have learned to do so by taking a model and painstakingly imitating it. Such was the case with Scott. It was so with Stevenson. It was so with Lincoln. In a newspaper office the cub learns to write his "story" in the same way. It is a matter of imitation. It has always been so. Yet in the face of such overwhelming evidence that English expression is an

Digitized by Google

art, it is treated as a science for the sixteen years of a student's life in the public school. Scarcely has the child learned to read before he is given a grammar and made to study sentence-structure. At first it is called language as a sort of camouflage; but it is grammar, the science of language; it is the study of the principles on which expression is based rather than practice in expressing himself. It is not even correct science, for in this early work he learns grammar as something illogical. He does not take grammar up as logic. Till he goes through the eight years of the common school he is year by year exposed to this dose of illogical grammar in the hopes that he may in some manner learn to write and speak; and in just a few cases he learns, but not through anything that the school does. He learns as a by-product; and for this reason there has grewn up a sort of uncanny belief that writing is a gift confined to a few individuals, that the ordinary student can not learn to express himself.

Nor did the grammar obsession cease with entrance to high school. For many years there was a shift in the point of view. From the science of the sentence the emphasis shifted to the science of expression, from grammar to rhetoric. But of late years there has been a rebound back in the other direction; the public, knowing only that high school graduates could not express themselves when they got through school, and not being in a position to know that they never could write by the study of grammar, demanded grammar in the high school; and now we have grammar in the high school; but still our students cannot express themselves.

Science in the grades; science in the high school; and in the university and college what? Some years ago the student was just asked to write—two short themes per week. Yes, you remember "English 7." You were supposed to produce two themes per week; after twelve years of the study of grammar and rhetoric you were supposed to be filled to the brim and thus to be able to write; but you could not. Do you remember your instructor in this course? He was a young fellow not yet versed in teaching anything; and he stormed; he realized that you could not write; he felt his own inability to teach you, and he blamed the high school and the grammar school. He was right.

But the public was not satisfied with that. The public awoke to the fact that not only were grammar school and high school graduates unable to express themselves in the English language

Digitized by Google

but that college graduates as well were short in that line. Then the public demanded grammar and got grammar. Now we have grammar in the college as well as in the grammar school and the high school; and still our students cannot express themselves.

Thus stands the first great indictment of our English teaching. It is taught as a science and not as an art.

What is the next outstanding fact in poor English teaching?

I realize that my statement may seem a heresy. But if I am to analyze this problem with any hope of reasoning from effects back to causes and thus to find a remedy, I must state facts as they appear to me. The next outstanding fact is that teachers of English cannot write. I am not stating this as an absolute fact. I do not have positive evidence. My evidence is negative. I have reached this inductive conclusion by reason of the fact that I have had forced upon me the absolute dearth of writings by teachers of English. It is true that we find a few scattered writings in school journals. But how few these are in proportion to the number who are teaching English. If my induction is correct, this in itself would be enough to make impossible the teaching of expression to students; for the very essence of teaching an art is some skill in that art on the part of the teacher. Imagine a man in a factory trying to teach something he himself cannot do.

My experience has been that the average teacher of English looks upon the teaching of expression with aversion. He delights in teaching literature; but he prefers that his colleague shall teach expression. But is he to be blamed for it? We have been going round in a cycle. His teacher before him was taught grammar; his teacher before him could not write. Our teachers have not been taught to write. It is not their fault. It is the fault of the system.

There is another outstanding fact connected with the teaching of English. Not only can our teachers of English not write. They cannot think inductively and deductively. I have in mind one man in particular who is making a desperate effort to solve the problem of teaching junior collegians how to write. He confesses that he cannot understand argumentation. He can make only a pretense of teaching it. One has only to glance through the average rhetoric to see that inductive and deductive thinking have not yet become a part of the equipment of the teacher of English or of the writer of so-called rhetorics and composition books.

Digitized by Google

In connection with this same thought comes another which is difficult to place. Teachers of English as a class are not broadly enough trained. We are coming to believe now that every boy and girl should have general science, that each should be grounded in economics and history. Just how can a teacher of English hope to teach expression if she is not grounded in the fundamentals of all the sciences? Yet in my own experience I find so few teachers of English who are really interested in the subject matter of other departments. When a discussion in botany or some other science is brought up, they seem bored, as if the discussion were something not germaine to their work at all.

Now, I have touched upon what seem to me to be the most vital points connected with the teaching of English. I have painted a rather drab picture; but it is not the drab of hopelessness. I have said that expression must be taught as an art. In spite of all the despair which seems prevalent in trying to teach it in the manner which it has been taught and is being taught to a great extent, the teaching of it as an art is not only simple but is to the person who himself takes a joy in expression, a joy. It consists merely in giving the student a model to work from and having him copy that faithfully. This must be done over and over again. From this he will go gradually to original work and the change will be so gradual that he will not know when it comes. But this expression must be at frequent intervals —daily, if possible, and must be read word for word and graded. By such a method a student can be taught to write in less than a week. That does not mean that he knows all that there is to know; but it means that he can write, just as after he tries for a certain time he can ride a bicycle. It is so very, very simple that once he sees how to do it he can scarcely realize why he considered it difficult. I am tempted to go into detail concerning devices and means at this point, but such is out of the scope of this article.

I have further said that teachers themselves cannot write, that they do not think in logical terms, that they as a class have not a broad enough interest in the subject matter of other departments. If we grant that my indictment is a true bill, the remedy is not hard to find. I have already indicated that a shift from the science side to the art side will make all the difference in the world; our teachers cannot write; then, if we are to produce writers of our students we must either find teachers who can write or train the ones we already have to do

Digitized by Google

so. If our teachers cannot think logically, we must get teachers who can do so or we must train the ones we have to do so; if they have not a broad foundation for their work we must either get teachers who have or we must convert our present teaching force into one with a broad foundation. Ideally, we need to go out and induce that great body of men and women who are writing for our newspapers and magazines to come into our schools and teach our students how to write.

Here in the school of Engineering of Milwaukee we are working on the problem intensively. We have a group of teachers of English who have been chosen for a particular work, that is to teach students to read and to express themselves. We have no ruts in which we must keep. We must produce results. In a short time we shall be able to give to our friends some few results of the experiment: In conclusion, I wish to add to what I have already said that our spirit here is that we do not wish to be considered as a department in ourselves. Our department is a handmaiden of the other departments. We consider it our business to see that our freshman students can read their general science text. We go on the theory that they know only that which they can express in clear English. We take it as our task to train students to read chemistry, physics, and botany. Certainly this means that we must become familiar with these texts ourselves. If we ask a student to write a theme on the dry cell, we must be able to do so ourselves. It is work—hard work; but just as in a newspaper office at the close of the day one has in front of him his day's work in black type, we have here at the end of the day a direct check of our efforts. Then, too, from out of this we think we shall evolve a technique that will make for a keener appreciation of literature than students have usually, because all that we do must be based on truth; we may not pretend; we may not be hypocrites. Of the sunrises, the snows, and rains, the mud, the smoke, and the hundreds of sights and sounds and smells that come to us each day we are certain of appreciation. This is literature. Our students sense it as such. They are learning to read and appreciate and enjoy; they are learning to express themselves simply and clearly; for they are working on expression as an art, and we have the fear of falsity too much in our hearts to ask them to express something that we ourselves cannot express; by our rigid training in science and economics and education and philosophy we have been forced to think logically, inductively and deductively; we must have a broad training.

Digitized by Google

STEPS NECESSARY TO ESTABLISH GEOGRAPHY AS A FUNDAMENTAL HIGH SCHOOL SUBJECT.[1]

By F. E. WILLIAMS,

University of Wisconsin, Madison, Wis.

A man's worth to the community is measured by his ability to meet and solve the problems which arise in a time of crisis. In like manner may the value of a science be appraised. If a science furnished its quota of strong, capable men in the hour of need, it has proven its right to exist. In the struggle which involved the whole world did geography furnish its quota of trained men and did these men acquit themselves creditably in the fields to which they were called? We can answer both of these questions in the affirmative and further affirm that men of geographical training were often the leaders and among the first to suggest profitable and valuable problems to be solved.

Geographers were called into all branches of war work. Their names will be found high upon the roster of practically all branches of service—some in uniform, many not, but all working with the zeal and intellect which they had developed while studying in a field that not only promotes clear thinking, but inspired high ideals of citizenship. Because of their knowledge of resources, demands, and transportation problems, perhaps no group of scientists more clearly understood the difficulties which confronted the nation. It is unnecessary to enumerate the different organizations in which geographers served or the names of the men who discharged their duties with precision and often with distinction. A practically complete list of these men may be found in an article by Professor Whitbeck read before this section last year and published in "School and Society," February 22, 1919. Many other geographers received urgent calls to go into similar lines of work, but they could not be spared from the departments, already much weakened, of the higher educational institutions of the country.

And the call for geographers continues. If one had suggested a few years ago that geography might become a "bread and butter" study, he would have met with ridicule. Yet within the last year several geographers have been offered and some have accepted positions carrying salaries that would make the average faculty man feel that the millennium was at hand. Even

[1]Read before the Earth Science Section, C. A. S. and M. T., Lake View High School, November 29, 1919.

Digitized by Google

the United States Geological Survey comes out with an announcement of an examination for "Mineral Geographers," no doubt suggested by the excellent work of the geographers and by the geographical knowledge of the geologists which was of such great value to the government in the recent crisis.

With such evidence before us, it should be easy to firmly establish geography in the high schools. It has just been demonstrated that it is one of the studies which has high practical value as well as intellectual discipline. It can be more clearly pointed out now, more clearly than ever before, that geography is one of the studies that makes for potentiality and good citizenship. By geography I mean the kind of geography which makes us familiar with the resources, the broader lines of historical development, the institutions, and the inclinations of the peoples of the world. It is a trite saying that "This is the day of the specialist," but never was the world more in need of the specialist who has a broad enough education to be able to think nationally and internationally.

What geography most lacks is a past—a past to give it equal prestige with other sciences. It is true that we have had many different types or divisions of geography taught for many years, but there is not, in the minds of the public, a clear idea of what is meant by geography if, indeed, there is unanimity of opinion among geographers themselves. It seems, however, that geographers at present are pretty generally agreed on the fundamentals to be emphasized in the teaching of geography. In your department of earth science you have proposed "that the aims of geography teaching shall be tentatively classified as:

"(1) Understanding, appreciation, and control of the pupil's daily environment,

"(2) Training in ability, such as problem seeing and problem solving,

"(3) Acquisition of a fund of information pertaining to the countries and peoples of the world,

"(4) To get a setting for the interpretation of English and history."

You have then put yourselves on record as favoring regional geography (local, sectional, national, or world wide) so developed as to bring out the relationship of geographical environment to progress and development. With this, I believe, most geographers heartily agree. Having reached an agreement, let us stand for the development of geography as if we believed in it.

Digitized by Google

Too long have we as geographers attended educational meetings and defended the teaching of geography when we should have been presenting ideas to be taught. How many pages of the geographical journals and other educational papers have been given over to the defense of one or many phases of geography as a high school subject? Perhaps much of this was necessary in the past, but it is certainly unnecessary now. No longer need one blush when called upon to admit that he is a teacher of geography. People in general have little faith in a man who does not believe in himself. If we would firmly establish geography and give it the prestige it deserves, let us get together and stand for the principles we have established so that others seeing may believe that our science is as valuable as the best. The papers presented here show that you no longer are seeking to justify geography but are seeking to enrich and enforce its content so that it will have a present, and the future will find it with a well established past.

Another lack that has been serious for geography has been the want of a good textbook. True we have had several good texts in physical geography and commercial geography, but it was only very recently that any attempt was made to write a text along the lines suggested by your committee. There are now several manuscripts about ready for the printer and doubtless more will follow. A good text book is necessary to act as a guide as well as to supply principles and facts. Of course, the established textbook should be supplemented by other textbooks, special papers, periodical literature, and government publications. At the University of Wisconsin, at the beginning of the present semester we were forced to proceed several weeks without textbooks as they were not available. The result was harder work for the instructors, poorer results as to the facts learned, but worst of all was the effect upon the students in regard to their attitude toward the course. The textbooks were received about six weeks after the beginning of school, and we are finding it quite difficult to get the students down to real work in a course where the instructors were compelled to lecture and quiz upon their own words. True the work was unusual on account of the exceedingly large enrollment, but in general very few students below the junior class in college or the university are able to do effective work without some kind of a textbook. It becomes a sort of clearing house for facts assembled from other sources and is an ever present port in time of

Digitized by Google

storm when disputes arise and examinations threaten. Let us see to it then that the textbooks which appear fulfill the requirements of a good sound geography course however much they may differ in detail. Newspapers and periodicals influence public opinion. Geographers and other science teachers must influence boards of education in their choice of textbooks. Otherwise, geography will lose this wonderful chance to become firmly established on a par with the other sciences. In order to do this it will be necesssary to write, talk and act. Above all, always be on the alert that some book company through its agents does not put over a text that is unteachable or omits the essentials which make geography a living, interesting, and recognized study. Adoption of poor textbooks at this time would do much to lower the prestige which geography has recently attained.

Important as a textbook is, we must have someone to interpret it and supplement it. So our greatest factor of success enters in the person of the teacher. A teacher may make or break the vantage gained. Geography is so closely interwoven into the economic and industrial problems of the day that its teachers must not idle for an instant. It is not enough to teach the textbook facts, they must be supplemented by up-to-date articles of world interest. Geography cannot confine itself between the covers of any book so it must have an especially wide awake teacher who is always on the lookout for interesting facts. Too long has the class in geography in the high school been shifted to the teacher with a free period.

Successful geography can only be taught when the teacher is on the alert constantly for new material, so, necessarily, it cannot be placed in the hands of one who will treat it only as a side issue. A poor teacher is a stumbling block to the advance of any subject but how much more is this true in geography. The teacher of the average science must be a specialist through long attentive work in his particular study. But the geography teacher must have a background before any specialization can be made. One cannot teach geography, especially the most interesting phases, as taken up in courses of human response and geographical influences without a firm foundation in history dealing particularly with exploration, settlement, and progress, as well as a knowledge of the soils, plants, minerals, and configuration of the land.

But no amount of specialization will ever make a perfect teacher unless alertness and observation and initiative are there.

Digitized by Google

There is such a fund of geographical facts in every periodical that any good magazine dealing with world topics contains a vast amount of useful material that enriches the student's knowledge. While studying the harbor of New York, some time ago, I referred my class to an article in the *World's Work* for December, 1915. One of my students was much interested in some facts which he acquired about Colombo. He knew nothing of the city before, and its large shipping tonnage in graphite particularly took his attention. This opened up to him an especial interest in Colombo and graphite which he followed up and enlarged upon. The teacher must never fail to utilize opportunities to awaken an interest in up-to-date matters and put the pupil in touch with the best thinkers and writers who are studying the questions of the day.

The position which geography has reached in the colleges, and universities is a further aid to the establishment of this study in the high school. For years advocates of the teaching of geography in the high school have had to fight for recognition from the higher institutions of learning. As a high school study it should now receive an impetus from these higher institutions where it is now permanently established. Boards of education find it prominent among the studies in the catalogue. Graduates are going out to proclaim its usefulness. In these institutions are trained the men and women who must present geography in such a way that the most skeptical will be convinced of its value. The number of students taking geography in the universities has increased by leaps and bounds. In the University of Wisconsin the rate of increase has been several times as great as the rate of increase in total attendance. Let us compare the records of 1916, the last year before we entered the war, with those of the present year. In 1916 the attendance, excepting the summer school, was 5,318. In 1919 the attendance is about 7,000. This shows an increase of a little over 31 per cent in total enrollment. In the first semester of 1916 there were 542 students enrolled in geography, while at present there are 1,156, a gain of over 113 per cent. Such an enrollment in geography in the university cannot help but stimulate its growth in the high school.

A more opportune time could scarcely be found for the establishment of geography in the high school. In constant demand are the men who know the principles underlying the production, transportation and delivery of commodities.

Digitized by Google

INTRODUCTORY COURSES IN BOTANY IV.

By Bradley M. Davis,
University of Michigan, Ann Arbor.

(Continued from January, 1920.)

Outline No. 11.

A year's course, seven periods a week, primarily for first or second year high school pupils, but sometimes adapted to other years.

1. Problems in water relations of plants. a. Evaporation from plants. b. Transfer of water and the structures involved; stem structure and characteristics of woody stems. c. Absorption of water; root structure; osmosis.

2. Problems in nutrition. a. Carbohydrate manufacture, and the anatomy of the leaf. b. Leaf arrangement as related to photosynthesis. c. Independent plants. d. Saprophytes and parasites. e. Use made of elaborated food; digestion, transference, storage, assimilation.

3. Problems of growth, propagation, and reproduction. a. Opening of bud and growth of shoot. b. Structure of buds. c. Utilization of stored food. d. Growth from tubers, bulbs, etc. e. Stolons, runners, root sprouts. f. Leaf cuttings, soft wood and hard wood cuttings. g. Flower and seed; pollination, fertilization.

4. Dispersal and germination of seeds. a. Methods of dispersal; field and laboratory study of effectiveness of devices. b. Growth from seeds. c. Structure of seeds.

5. Response to environment. a. Response to temperature, gravity, light, touch. b. Competition between plants and between branches on the same plant. c. Healing of wounds; callus formation; tree trimming. d. Transplanting.

6. Dependent plants, social and economic problems. a. Bacteria; relation to decay and disease. b. Yeast; physiology and morphology. c. Molds; growth, distribution and structure. d. Parasitic fungi and plant diseases. e. Mushrooms. f. Wood-rotting fungi.

7. The principal groups of independent plants. a. Algae; vegetative structure, manner of life, reproduction. b. Mosses; vegetative structure, the problems of water supply and nutrition, gross anatomy of reproduction. c. Ferns; vegetative structure, the problems of water supply and nutrition, asexual reproduction. d. Gymnosperms; vegetative structure, water supply and nutrition, gross morphology of reproduction. e.

Digitized by Google

Angiosperms; review vegetative structure and methods of water supply and nutrition; study flowers and seeds as supplementary to earlier study of same subjects on account of greater seasonal abundance of material.

8. Problems of industries founded upon plant activities. a. Plant breeding problems. b. Soil and its problems. c. Weeds and the problems of weed control. Much discussion of the relations of plants to industries and particularly to agriculture is involved in earlier parts of the course. Only problems requiring additional separate treatment appear here.

9. Plant geography. a. Local problems. b. Regional distribution. The amount of attention given to this section must vary widely, due to differences in local problems, age and grade of class, amount of time available, school program, and library equipment. They cannot be outlined in advance.

"The course is administered with the knowledge that only a negligible minority of those who take botany in a public high school will ever study it in college. It is organized fundamentally about the life of the plant and the problems of social significance involving plants. Function precedes structure in order of presentation, but structures are studied when, and so far as, desirable in order to understand the work of plants and their relations to human welfare."

"With a class of very immature pupils, as an exclusively ninth grade class, many of the topics must be somewhat simplified. This is particularly true of Section 7. On the other hand if the class is made up largely of third and fourth year pupils this section may be considerably amplified."

OUTLINE No. 12.

A year's high school course, seven periods a week, forty-five minutes to a period.

1. General structure of a simple seed plant such as Bouncing Bet to obtain an understanding of root, stem, and leaf regions, their functions, and the structure and functions of a simple flower. (No details of morphology)

2. Careful laboratory studies on two types of composite flowers.

3. Herbarium collection made by the class as a whole of common autumn garden flowers, classified as simple or composite, and named with the aid of florist's catalogues.

4. Weeds. Field trips for identification and careful study to determine reasons for their success. Study of vegetative

Digitized by Google

reproduction. Calculations of numbers of seeds to individual plants. Herbaria of weeds.

5. Pollination. Study of various adaptations of flowers to different agencies of pollination. Field work to observe insects visiting flowers.

6. Seeds. Methods of dispersal. Service to plants. Uses to man.

7. Field work on identification of common trees by their leaves (emphasis on parkway trees). Leaf division. Venation. Margins. Herbaria of leaves of trees.

8. Forestry problems (illustrated with lantern slides). Laboratory work on useful woods, study of wood grain, weight, uses to man.

9. Plant societies. Demonstrations with lantern slides. Field trips to the three types of plant associations.

10. Fall gardening. Bulbs, cuttings, etc. Laboratory work on the care of house plants.

11. Algae. Microscopic work to show evolution of plant body from single cell to cell mass. Evolution of reproduction, fission, asexual spores, sexually formed spores. Osmosis, plasmolysis. Photosynthesis. Algae from an economic standpoint. Demonstrations of brown and red algae.

12. Bacteria. Agar-agar, broth, potato cultures. Study of methods of food preservation with laboratory experiments. Microscopic study of living bacteria raised in hay infusion. Economic importance. Relation to disease.

13. Fungi. Raising of molds. Study of structure, reproduction, and life habits of bread mold. Life history of wheat rust. Economic importance of fungi.

14. Evolution of seed plants through a brief study of bryophytes for alternation of generations and of pteridophytes for vascular system and the development of complex sporophytes. Economic importance of these groups, peat, coal.

15. Gymnosperms. The seed. Structure of leaves which permit indeciduous habit. Economic importance of group from the standpoint of lumbering and naval stores. Collection of evergreens.

16. Deciduous trees in winter. Structure of buds and twigs. Identification of trees from twigs with field work on identification of trees in winter conditions.

17. The seed. Types. Structure and germination. Seed testing. Experiments on food storage and vitality.

Digitized by Google

18. Soils. Microscopic structure and simple analysis of soils found in yards of pupils. Experiments on water content and temperature as affected by color, slope, air spaces, etc.

19. Seedlings. Study of various types germinated in different soils. Stages of development. Response to various stimuli, light, gravity, etc., to be worked out by experiments. Respiration. Digestion of starch by germinating barley.

20. Root structure. Study based on radish seedlings and other material. Tests for food storage in turnip, parsnip, etc. Economic importance of roots.

21. Stem structure. Arrangement of tissues in various types. Food storage tests. Experiments on girdling, food transportation, cuttings, grafting. Economic importance of stem products, rubber, etc.

22. Leaf structure. Microscopic study of stomates and cross section of a simple leaf such as the lily. Experiments in photosynthesis. Comparison of leaves of desert plants with those of water plants, with those of garden plants. Transpiration.

23. Gardening. Each pupil to raise at least three kinds of vegetables one of which is to be a succession crop. Plot prepared to scale.

24. Study of fertilizers. Experiments with seedlings.

25. Preparation of soils.

26. Study of vegetables chosen by the majority of the class. Their origin, requirements, methods of planting, care, diseases, insect pests, harvesting, food values.

27. Spring flowers. A few plant families. Emphasis on classification. Use of scientific keys.

28. Fruits. Structure and development from flower. Pollination and plant breeding. Mendelism. Study of cereals with special emphasis upon wheat and corn, and their breeding. Importance as food.

"High school botany should emphasize that which is of importance to pupils who have not yet had much scientific training by dealing with topics of everyday experience in such a way as to develop a scientific attitude. To keep the plant before the pupil as far as possible as an intact living thing, many opportunities are offered in the way of caring for plants in and outside of the laboratory. Where there is not sufficient space available in the school garden, pupils who have sufficiently large home gardens may be given credit for them. This demands

Digitized by Google

personal visits on the part of the instructor, but the results are well worth the time expended."

OUTLINE No. 13.

A year's high school course in an agricultural region, eight periods a week, forty-five minutes in a period.

1. Study of a plant as a whole. The parts and their functions. Life history.

2. Seeds. Structure and germination. Seed dispersal. Seed testing, agricultural application. Propagation by seeds. Weeds, dispersal by seeds, identification, extermination. Kinds of food in different seeds, tests of foods.

3. Fruits. Study of four different types of fruits. Comparative and diagramatic work.

4. Bacteria. Structure, growth, etc. (experimental and topical). Uses of bacteria in various industries, visiting such as are available. Uses of bacteria in agriculture, soil fertility. Most common bacterial diseases, how spread, symptoms, prevention. Bacteria and dairy products.

5. Yeast. Structure, growth, etc. (experimental work). Fermentation. Vinegar production.

6. Algae. Study of a few common forms. Study of the cell.

7. Molds. Structure and life habits.

8. Mildews. Structure and life histories. Hosts, losses, how prevented. Various fungal diseases on potato, different trees, shrubs, etc.

9. Smuts. Life history, losses, preventives on grain and corn.

10. Rusts. Life history, losses, preventives on cereals.

11. Mushrooms. Life history and importance.

12. Lichens (very briefly).

13. Mosses. Life history and importance.

14. Ferns. Life history, importance, coal.

15. Equisetum. Life history, former importance, coal.

16. Gymnosperms. Life history. Structure of stems in detail as introductory to stems of angiosperms. Economic importance.

17. Roots. Main classes. Anatomy. Physiology, absorption, osmosis, etc. Ecology. Soils, composition and formation, water in soil, enriching soil, rotation of crops, irrigation and dry farming. Topical work based on magazine articles, planning of farms, intensive farming, conservation.

Digitized by Google

18. Stems. External morphology. Internal structure. Physiology. Ecology. Grafting, etc.

19. Leaves. External features of foliage leaves. Physiology, experimental studies. Ecology.

20. Buds. Winter and spring conditions. Morphology. Physiology.

21. Flowers. Detailed study of several representatives. Mechanism for pollination. Relations of insects to pollination. Field work.

22. Plant breeding. Principles. Work of prominent breeders.

23. Monocots and dicots. Difference in structure. Main economic groups.

24. Forestry. Classification and identification of common local trees, field trips. Uses of trees. Principles of forestry. Conservation, topical reports.

25. Gardening. Principles of gardening. Practical work in hot beds and gardens if possible; in which case the subject must be introduced earlier.

26. Orcharding. Fruit raising, etc.

"This course aims to teach the important facts over the whole field of botany with reference to structure, physiology, evolution and ecology. Special emphasis is laid throughout on economic and practical knowledge such as the student can use directly in his garden and farm work. Current magazines, bulletins and reprints are used as constant reference material."

OUTLINE NO. 14.

A year's high school course, seven periods a week, forty minutes to a period.

First Half Year:

1. A general study of a simple plant such as nasturtium or Bouncing Bet, sunflower or other composite followed by an exhibit of many composites.

2. Study of one weed selected by the pupil with exhibits of numerous weeds tabulated in outline form giving name, where found, annual or ?, how seeds are scattered, harmful to ?, how controlled, etc.

3. Autumn fruits. Studies of dry and fleshy fruits, nuts, pods, burs, akenes, berries, pomes, etc. "Apple show," a study of all available varieties for variation in color, shape, flavor, use, etc.

Digitized by Google

4. Bulbs. A two-day study of bulbs suitable for autumn planting and of methods of forcing winter blooming bulbs, followed by the care of at least one paper-white narcissus plant through blooming.

5. Bacteria. The plating of many cultures of bacteria from water, milk, air of cars, stores, class room, etc. Transfer of cultures to gelatine and agar tubes. Staining of bacteria. (Media prepared by the instructor.)

6. Algae. Structure and reproduction of Pleurococcus and Spirogyra. Exhibit of algae.

7. Fungi. A study of yeast and mushroom.

8. Moss. Structure, reproduction, and life history (optional).

9. Fern. Structure, reproduction, and life history.

10. Gymnosperms. General study of coniferous types, pine, spruce, hemlock, fir, etc.

Second Half Year:

11. Seeds and seedlings. Study of bean, corn, and pine; economic uses of seeds, tests on food content, vitality, various tropisms.

12. Roots. Absorption, storage, modified types.

13. Stems. Structure and function, modified types, economic importance. Study of woods and identification of trees in winter condition.

14. Leaves. Structure, photosynthesis, transpiration, storage, modified types.

15. Flowers. Structure and function of flower parts. Study of families, willow, arum, lily, mustard, violet, legume, figwort, rose, composite. Competitive reports on flower calendar covering wild and hardy cultivated plants.

" The prime object of the course is to stimulate the pupils interest in plants as factors in the present and future years of his life, featuring his dependence on plants for his existence and comfort, in other words to encourage a living interest rather than to foster a memory of botany finished."

OUTLINE NO. 15.

A half-year high school course, five periods a week, forty minutes to a period.

1. Morphology of common plants. The structure, modifications, and uses of roots, stems, buds, leaves, flowers and fruits.

2. The physiology of roots, stems, leaves, and seeds.

3. Commercial products obtained from roots, stems, leaves, fruits, and seeds.

Digitized by Google

4. Trees. Identification of common trees both in their winter and summer condition.

5. Soil study. Composition and origin of typical soils. Drainage, tillage, fertilizers, and crop rotation.

6. Wild flowers. Identification and habitat of common wild flowers.

7. Identification and field study of weeds common to fields and garden.

8. Decorative planting and garden planning. Principles governing the arrangement and choice of plants used in garden and on lawn. Rules for planting vegetables; care of soil, hot beds, cold frames.

9. Plant breeding. Natural and artificial methods of producing new fruits, grains, and flowers.

10. Seeds, seedlings and fruits. Types of seeds, fruits and seedlings.

11. Plant ecology. Influence of light, water, and soil. Plant associations.

12. The cell. Its structure and the properties of protoplasm.

13. Algae. To demonstrate cell division and conjugation, and the increase in complexity of the plant body. Their economic value to aquatic life and to man.

14. Fungi. As dependent plants; their methods of reproduction and their relation to disease in both plants and animals. Edible and poisonous mushrooms.

15. Field trips. Trips to be taken in season during school hours and on Saturdays for the study of trees, wild flowers, weeds, fungi, etc.

"This short course in botany for second year students in a high school of a large city aims to stress the economic side of the subject, since that is demanded in this particular school. At the same time the teacher is trying to present the subject in a scientific spirit, to give the student an idea of the plant as a living, working organism, to open the student's eyes to an interest in plant life as they see it about them in their walks to and from school, in the parks, in their visits to the country, and in their backyard gardens, if they are fortunate enough to possess a backyard."

OUTLINE NO. 16.

A half-year course of high school grade to prepare for a study of farm crops, three recitations, two laboratory periods each week.

Digitized by Google

1. Algae. Study of two types, sexual and asexual reproduction.

2. Bacteria. Rather extensive study with special reference to those that concern the farmer in plant disease, dairy practice, etc. Nitrifying bacteria.

2. Fungi. Study with special reference to those that cause plant diseases such as wilt, scab, blight, smut, rust, etc.

4. General studies on mushrooms, lichens, liverworts, mosses, and ferns so that the pupil may be able to recognize them but without details of organization.

5. Brief study of gymnosperms taking up those of importance on farm wood lots.

6. Plant physiology. Based on study of cells, leaves, vascular bundles, root hairs, etc. Osmosis, transfer of materials, photosynthesis, etc.

7. Foods manufactured by the plant with a study of various grains and their analysis.

8. Water relations of plants and how man may conserve water.

9. Study of soils, humus, fertilizers, etc.

10. Comparative studies on monocots and dicots with identification.

11. Types of roots, tubers, bulbs, stems, fruits, etc., with classification of those that are raised on the farm.

12. Fertilization, cross pollination compared with self pollination, plant breeding, mutations.

13. Practical studies on budding, grafting, cutting, etc.

14. Laboratory studies on samples of fertilizers.

15. Field trips for the study of weeds.

16. Visits to some of the best farms in the neighborhood.

(*To be Continued.*)

For the first time at the University of Cincinnati, College of Commerce students are admitted on a co-operative basis. The co-operative experiment has proved so successful in the Engineering College that it was decided to extend its application. To make greater the probability of success, the co-operative feature of the College was placed under the control of Dean Herman Schneider. There are now 500 Co-ops in the Commerce College and the system seems to be working nicely. The upward bound in registration applies to the night as well as to the day Colleges. More out-of-town men and women than ever before are seizing the opportunities furnished by the University for getting an academic education by night study. The night College has brought the University into touch with the working people and makes it more popular with the rank and file of the citizenry of the city. Late returns are expected to bring the total enrollment to 800 students in the night courses.

Digitized by Google

A SUGGESTION FOR TEACHING THE ABSOLUTE ZERO.

G. W. WARNER,

Englewood High School, Chicago.

In the following exercise no claim is made for anything new either in the apparatus used or in the method of performing. But by use of the questions given below, the writer thinks he has had better success in teaching the fundamental ideas of the absolute zero and the absolute temperature scale than by the use of any of the published laboratory exercises or text book discussions.

The ordinary type of constant volume air thermometer was used and the usual precautions were taken for drying the air and securing accurate results. The students were just beginning the study of heat, two days having been spent in discussing the difference between heat and temperature and in becoming familiar with the use of the Fahrenheit and Centigrade scales. In each section the experiment was performed as a class exercise, three students doing the work under the direction of the instructor, the remainder of the class observing and working out the results. In no section was the per cent of error greater than three per cent; hence the experiment was satisfactory both from the standpoint of accuracy and of knowledge gained. The outline follows:

THE PRESSURE COEFFICIENT AND ABSOLUTE ZERO.

Purpose: To study the effect of change of temperature of a quantity of air on the pressure which it exerts, the volume being kept constant.

Apparatus: Constant volume air thermometer, barometer, steam bath, ice bath.

Data and Results:

Barometric pressure today, B, = cm.

Bulb in ice

Height of mercury in closed arm, H', = cm.

Height of mercury in open arm, H'', = cm.

Pressure on inclosed air, $P_f = (H''—H') + B$ = cm.

Bulb in steam

Height of mercury in closed arm, H', = cm.

Height of mercury in open arm, H''' = cm.

Pressure on inclosed air, P_b, = $(H'''—H') + B$ = cm.

Total change of pressure, $P_b—P_f$, = cm.

Digitized by Google

Total change of temperature = 100 Centigrade degrees (Approx.)
Change of pressure per degree change of temperature for each centimeter of pressure at freezing, $\frac{P_b - P_f}{100\ Pf}$, = . This number is called the pressure coefficient. What two assumptions have been made in determining it?

Draw a graph of the results using temperature as abscissas and pressure as ordinates, and extend the graph backward through the Y-axis until it cuts the X-axis. Call this point A. What third assumption has now been made? Why are two points sufficient to determine this graph? What pressure would the inclosed air exert if the temperature were reduced to that represented by point A? According to the kinetic theory what is the cause of gas pressure? What must be the condition of the molecules of the gas at point A? What is their kinetic energy of translation? Explain. Assuming that heat is kinetic energy of translation of molecules, how much heat has the gas at this point? This point is called the absolute zero. Define it using the kinetic theory idea just developed. From your graph what is this temperature on the Centigrade scale? Calculate it using your pressure coefficient. What is the accepted result? What is the freezing point on the Absolute scale? Boiling point?

NEWS ITEM FROM THE NATIONAL RESEARCH COUNCIL.

A special committee of the National Research Council, consisting of Dr. R. M. Yerkes, chairman, and Dr. M. E. Haggerty of the University of Minnesota, Dr. L. M. Terman of Stanford University, Dr. E. L. Thorndike of Teachers College, Columbia University, and Dr. G. M. Whipple of the University of Michigan, with financial support from the General Education Board, have formulated a plan for using the army mental tests in schools. Such intelligence tests have been used in schools for some time on individual children, but the new plan provides for handling them in groups, even whole class-rooms at a time. The committee selected about twenty tests for careful trial. This trial was made on five thousand children. As a result the committee has now been able to select from the tests two series which seem to be the most satisfactory and these will now be tried on several thousand more children in order that they may be further perfected before they are finally offered to the teachers of the country for general use.

This carefully worked out program for group tests will make it possible and practicable to make wholesale surveys of schools annually, or even semi-annually, so that grade classification and individual educational treatment can be adjusted with desirable frequency. The army tests, on which these new group tests for children are based, and which were used with striking success and advantage during the war, were originally devised by a group of psychologists working under the auspices of the National Research Council. This mailer may be obtained from the office of the Executive Secretary, 1201 Sixteenth St., Washington, D. C.

Digitized by Google

NATIONAL ACADEMY OF SCIENCES.

The Carnegie Corporation of New York has announced its purpose to give $5,000,000 for the use of the National Academy of Sciences and the National Research Council. It is understood that a portion of the money will be used to erect in Washington a home of suitable architectural dignity for the two beneficiary organizations. The remainder will be placed in the hands of the Academy, which enjoys a federal charter, to be used as a permanent endowment for the National Research Council. This impressive gift is a fitting supplement to Mr. Carnegie's great contributions to science and industry.

The Council is a democratic organization based upon some forty of the great scientific and engineering societies of the country, which elect delegates to its constituent Divisions. It is not supported or controlled by the Government, differing in this respect from other similar organizations established since the beginning of the war in England, Italy, Japan, Canada, and Australia. It intends, if possible, to achieve in a democracy and by democratic methods the great scientific results which the Germans achieved by autocratic methods in an autocracy, while avoiding the obnoxious features of the autocratic regime.

The Council was organized in 1916 as a measure of national preparedness, and its efforts during the war were mostly confined to assisting the Government in the solution of pressing war-time problems involving scientific investigation. Reorganized since the war on a peace-time footing, it is now attempting to stimulate and promote scientific research in agriculture, medicine, and industry, and in every field of pure science. The war afforded a convincing demonstration of the dependence of modern nations upon scientific achievement, and nothing is more certain than that the United States will ultimately fall behind in its competition with the other great peoples of the world unless there be persistent and energetic effort expended to foster scientific discovery.

MINNESOTA SUPERINTENDENT TO MANAGE CLARK AGENCY.

Word has just been received in this office that Superintendent Joseph V. Voorhees of Winona, Minnesota, has tendered his resignation to the Board of Education to take place as soon as convenient so that he may take up his duties as Manager of the Northwestern office of the Clark Teachers' Agency.

Mr. Voorhees is one of the best known superintendents in the state having been in Winona for the past eleven years, seven of which he acted as superintendent and four, as principal of the High School. During this time he has taught several consecutive sessions at the summer schools of the Michigan State Normal College, Ypsilanti, and the State Normal School at Winona, Minnesota.

The distribution of teachers is a function of prime importance to our educational system and it augurs well that one of the chief distributing agencies should choose a man of Mr. Voorhees capabilities and experience to assist in this important work.

The northwestern office of the Clark Teachers' Agency is well known to educators. Its merited reputation for expedited service has compelled the use of enlarged office space.

Permanent quarters have been secured on the fourth floor of the Globe Building of Minneapolis.

Digitized by Google

LARGE PRODUCTION OF PHOSPHATE ROCK.

The three minerals most needed to make our agricultural industry more productive and more prosperous are potash, nitrate, and phosphate. Most of the potash and nitrate we use is imported, but our domestic supplies of phosphate are abundantly ample to meet all our requirements, and for years we have been heavy exporters to Europe. The total quantity of phosphate rock sold in the United States in 1918 was nearly 2,500,000 long tons, having a value of more than $8,000,000, over twice as much as was produced in that year in all the rest of the world. Florida alone produced more than 2,000,000 tons, having a value of about $6,000,000.

A report on the phosphate-rock industry by R. W. Stone, which has just been published by the United States Geological Survey, Department of the Interior, gives the details of production in 1918 by states and by kinds of rocks, shows the world's production by countries and by years from 1910 to 1918, and includes tables showing exports by countries. The report also describes briefly the distribution, character, and methods of mining the phosphate-rock deposits in Florida, South Carolina, Tennessee, Kentucky, Arkansas, and the Western States, gives a resume of the foreign phosphate deposits, and a bibliography. A copy of the report can be obtained on application to the Director, United States Geological Survey Washington, D. C.

EXAMINATION BY THE GEOLOGICAL SURVEY OF REGIONS THOUGHT TO BE OIL AND GAS BEARING.

In predicting the possible discovery of oil and gas in any region the method now generally employed, with great success, is to examine thoroughly every feature of the geology of the region, especially the features that determine or affect the origin and accumulation of oil and gas; and next, to compare carefully the features thus disclosed with the features of the nearest fields in which oil is obtained from the formations found in the field just explored. Conclusions based on work of this kind done by thoroughgoing and competent geologists in many parts of the country score more than sixty per cent in the discovery of new oil and gas pools. This is roughly ten to one better than the old-style methods, which took little account of certain geologic details now known to be very significant; and as geologic investigation and experience in the oil fields go forward the percentage of success is increasing. Nevertheless, the drill must give the final answer to the question whether oil or gas will be found at any specific point in wildcat territory.

AMERICAN CONSUL FAVORS METER-LITER-GRAM.

Strong support for its metric standardization campaign has just been received by the World Trade Club of San Francisco from B. Harvey Carroll, American Consul at Naples, Italy. Mr. Carroll has written unofficially: "In more than a score of reports to the department, I have taken occasion to advocate the abolition of the imbecility of the English system of weights and measures and the adoption of the metric system." Mr. Carroll declares that he is in entire sympathy with the movement to secure metric standardization throughout the world. Many other American consuls throughout the world have expressed the same belief in metric standardization.

Digitized by Google

PROBLEM DEPARTMENT.

Publisher's Notice.

It is with great regret that we are obliged to announce the retirement of Dr. Hassler from the editorship of the Problem Department. Under his management it has attained great success. We are exceedingly fortunate, however, in securing Mr. Joseph A. Nyberg, of the Hyde Park High School, Chicago, to manage the affairs of this most important phase of this Journal.

Conducted by J. A. Nyberg,

Hyde Park High School, Chicago.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. If you have any suggestion to make, mail it to him. Address all communications to J. A. Nyberg, 1044 East Marquette Road, Chicago.

SOLUTION OF PROBLEMS.

636. *Proposed by Walter Warne, State College, Pa.*

Obtain all the values of x and y in the equations

$$x+y = 14-y^2,$$
$$x^2y^2+xy^2+xy = 600-x^2y^4-2x^2y^3$$

637. *Proposed by A. Pelletier, Ecole Polytechnique, Montreal, Can.*

A, B, C are three numbers having, respectively, α, β, γ digits. Find the number of digits in the expression $(AB/C)^n$.

[There was an error in the printing of these problems, and the corrected forms were not published in time for solutions to arrive. The solutions to these will be published at the same time as the solutions to the problems proposed this month—in September.—*Editor.*]

626. *Proposed by Walter McNelis, Philadelphia.*

Prove the following equations are consistent and solve

$$\begin{aligned} 50l_1+250l_2+100l_4 &= 6\\ 265l_3+200l_6-250l_2 &= 0\\ 110l_5-100l_4-200l_6 &= 0\\ 50l_1+265l_3+110l_5 &= 6\\ l_1-l_2-l_3 &= 0\\ -l_1+l_4+l_5 &= 0\\ -l_4+l_6+l_2 &= 0\\ l_3-l_5-l_6 &= 0. \end{aligned}$$

Solution by M. G. Schucker, Pittsburgh, Pa.

Equation (4) may be derived by summation of equations (1), (2), and (3). Hence, equation (4) may be neglected in the solution. The determinant of the other seven equations taken in order,

$$\begin{vmatrix} 50 & 250 & 0 & 100 & 0 & 0 & 6\\ 0 & -250 & 265 & 0 & 0 & 200 & 0\\ 0 & 0 & 0 & -100 & 110 & -200 & 0\\ 1 & -1 & -1 & 0 & 0 & 0 & 0\\ -1 & 0 & 0 & 1 & 1 & 0 & 0\\ 0 & 1 & 0 & -1 & 0 & 1 & 0\\ 0 & 0 & 1 & 0 & -1 & -1 & 0 \end{vmatrix} = 0.$$

Hence, the equations are consistent. Also, equation (8) may be derived from (5), (6), and (7). By solving the system of the six equations (1), (2), (3), (5), (6), and (7) as simultaneous,

Digitized by Google

$$l_1 = \frac{\begin{vmatrix} 6 & 250 & 0 & 100 & 0 & 0 \\ 0 & -250 & 265 & 0 & 0 & 200 \\ 0 & 0 & 0 & -100 & 110 & -200 \\ 0 & -1 & -1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 1 & 0 \\ 0 & 1 & 0 & -1 & 0 & 1 \end{vmatrix}}{\begin{vmatrix} 50 & 250 & 0 & 100 & 0 & 0 \\ 0 & -250 & 265 & 0 & 0 & 200 \\ 0 & 0 & 0 & -100 & 110 & -200 \\ 1 & -1 & -1 & 0 & 0 & 0 \\ -1 & 0 & 0 & 1 & 1 & 0 \\ 0 & 1 & 0 & -1 & 0 & 1 \end{vmatrix}} = \frac{5063}{194950}.$$

Likewise,

$l_2 = 2613/194950$; $l_3 = 7/557$; $l_4 = 2633/194950$; $l_5 = 243/19495$; and $l_6 = 2/19495$

627. *Proposed by Daniel Kreth, Wellman, Iowa.*

Prove that the integral part of $(1+\sqrt{2})^x$, x odd is a multiple of 4.

Solution by Norman Anning, Orano, Maine.

Let $(1+\sqrt{2})^x = A+B\sqrt{2}$ where A and B are integers.

Then $(1-\sqrt{2})^x = A-B\sqrt{2}$.

And $(1+\sqrt{2})^x+(1-\sqrt{2})^x = 2A$, an integer.

Now, since $\sqrt{2}$ is irrational, $(1+\sqrt{2})^x$ is not an integer and, because x is odd and because $1<\sqrt{2}<2$, the quantity, $(1-\sqrt{2})^x$, which is added to $(1+\sqrt{2})^x$ is a negative proper fraction; it follows that the integral part of $(1+\sqrt{2})^x$ is 2A.

Expanding $(1+\sqrt{2})^x$ and separating rational from irrational parts,

$A = 1+(x/2)\cdot 2+(x/4)\cdot 4+(x/6)\cdot 8+\cdots+[x/(x-1)]\cdot 2^{x-1/2}$

$A-1 = 2[(x/2)+(x/4)\cdot 2+\cdots+[x/(x-1)]\cdot 2^{x-3/2}]$

The binomial coefficient, (x/k), $(k = 2, 4, 6, \cdots, x-1)$, is an integer and since x is prime and greater than k it cannot cancel out when the denominator is got rid of and must remain as a factor of the integer (x/k).

Since $A-1$ is divisible by 2 and by x

$2A-2$ is divisible by $4x$. Q. E. D.

Note: Expressed as a continued fraction,

$(1+\sqrt{2})^x = 2A+1/2A+1/2A+1/2A+\cdots$

638. *Proposed by Walter R. Warne, State College, Pa.*

Show that

$$\begin{vmatrix} x, & y, & z, & w \\ a, & b, & c, & d \\ d, & c, & b, & a \\ w, & z, & y, & x \end{vmatrix} = \begin{vmatrix} (x+w), & (y+z) \\ (a+d), & (b+c) \end{vmatrix} \cdot \begin{vmatrix} (x-w), & (y-z) \\ (a-d), & (b-c) \end{vmatrix}$$

Solution by Helena M. Harrington, Saint Clara College, Sinsinawa, Wisconsin.

Multiplying column 4 by $(+1)$ and adding to column 1; multiplying column 3 by $(+1)$ and adding to column 2, we obtain

$$\begin{vmatrix} x, & y, & z, & w \\ a, & b, & c, & d \\ d, & c, & b, & a \\ w, & z, & y, & x \end{vmatrix} = \begin{vmatrix} (x+w), & (y+z), & z, & w \\ (a+d), & (b+c), & c, & d \\ (d+a), & (c+b), & b, & a \\ (w+x), & (z+y), & y, & x \end{vmatrix}$$

Multiplying the first row by (-1) and adding to the fourth row; multiplying the second row by (-1) and adding to the third row we obtain

$$\begin{vmatrix} (x+w), & (y+z), & z, & w \\ (a+d), & (b+c), & c, & d \\ (d+a), & (c+b), & b, & a \\ (w+x), & (z+y), & y, & x \end{vmatrix} = \begin{vmatrix} (x+w), & (y+z), & z, & w \\ (a+d), & (b+c), & c, & d \\ 0, & 0, & (b-c), & (a-d) \\ 0, & 0, & (y-z), & (x-w) \end{vmatrix}$$

Digitized by Google

By Laplace's Development

$$= \begin{vmatrix} (x+w), & (y+z) \\ (a+d), & (b+c) \end{vmatrix} \cdot \begin{vmatrix} (b-c), & (a-d) \\ (y-z), & (x-w) \end{vmatrix}$$

By suitable interchanges of rows and columns in the second determinant, we get

$$= \begin{vmatrix} (x+w), & (y+z) \\ (a+d), & (b+c) \end{vmatrix} \cdot \begin{vmatrix} (x-w), & (y-z) \\ (a-d), & (b-c) \end{vmatrix}$$

Also solved by A. PELLETIER.

639. *Proposed by N. P. Pandya, Amreli, Kathiawad, India.*

A quadrilateral ABCD has AB : BC : CD : DA = 1 : 2 : 3 : 4. On DA a part, DE, is cut off equal to 3AB. Find the condition that in the triangle BCE, CB = CE.

I. *Solution by T. E. N. Eaton, Redlands (Cal.) High School.*

Construct a right triangle whose hypotenuse is three times the short side and call the larger acute angle θ.

Draw AB ($=a$) making an angle with BC equal to $180° - \theta$. Complete the "kite" ABCE. On EC set up the isosceles triangle EDC, using $3a$ as the length of the sides CD and ED. Join EA. $\angle DEA$ is a straight line since $\angle AEC = \angle ABC$ by construction and $DEC = \theta$ by construction. Therefore the quadrilateral satisfies the hypothesis and EC = CB by construction. In brief, the condition is: $\angle ABC = 180° - \theta$ and θ = arc cos 1/3.

II. *Solution by Norman Anning.*

In the triangle CDE,

CD/3 = DE/3 = EC/2,

$\cos \angle CDE = (3^2+3^2-2^2)/(2\times3\times3) = 7/9$,

$\angle CDE = \cos^{-1} 7/9 = 38° 56\ 1/2'$ nearly.

Four sides and one angle are not quite sufficient to determine a quadrilateral. There is needed, further, the statement that it has or has not a reëntrant angle. This, along with 9cosD = 7 determine completely the quadrilateral of the problem.

Also solved by C. G. HUFF *and* A. PELLETIER.

640. *Proposed by Walter R. Warne.*

If $\alpha+\beta+\delta+\gamma = 360°$, change the expression

$$\cot(\alpha/2)+\cot(\beta/2)+\cot(\gamma/2)+\cot(\delta/2)$$

into a product in which δ is lacking.

Solution by Norman Anning, Orono, Maine.

If $A+B+C+D = 180°$,

$\cot A+\cot B+\cot C+\cot D$

$= (\cot A+\cot B)+[\cot C-\cot(A+B+C)]$,

$= [\sin(A+B)]/[\sin A\sin B]+[\sin(A+B)]/[\sin C\sin(A+B+C)]$,

$= [\sin(A+B)]/[2\sin A\sin B\sin C\sin(A+B+C)][2\sin C\sin(A+B+C)+2\sin A\sin B]$,

$= [\sin(A+B)]/[2\sin A\sin B\sin C\sin(A+B+C)][\cos(A+B)-\cos(A+B+2C)+\cos(A-B)-\cos(A+B)]$

$= [\sin(A+B)]/[2\sin A\sin B\sin C\sin(A+B+C)][2\sin(B+C)\sin(C+A)]$.

$= [\sin(A+B)\sin(B+C)\sin(C+A)]/[\sin A\sin B\sin C\sin(A+B+C)]$.

Putting $A = \alpha/2$, $B = \beta/2$, $C = \gamma/2$, $D = \delta/2$,

$\alpha+\beta+\gamma+\delta = 360°$

and $\cot\alpha/2+\cot\beta/2+\cot\gamma/2+\cot\delta/2$

$= \sin[(\alpha+\beta)/2]\sin[(\beta+\gamma)/2]\sin[(\gamma+\alpha)/2]\operatorname{cosec}\alpha/2\operatorname{cosec}\beta/2\operatorname{cosec}\gamma/2\operatorname{cosec}[(\alpha+\beta+\gamma)/2]$

a product in which δ is lacking.

A similar solution was received from A. PELLETIER.

LATE SOLUTIONS.

629. W. R. WARNE.

631. W. R. WARNE (4), C. E. GITHENS.

Digitized by Google

PROBLEMS FOR SOLUTION.

651. *Proposed by Walter R. Warne, State College, Pa.*

If x, y, z be in harmonic progression, a, x, b in arithmetic progression and a, z, b in geometric progression, show that

$$y = 2(a+b)\left[(a/b)^{1/4} + (b/a)^{1/4}\right]^{-2}$$

652. *Proposed by Walter R. Warne.*

A V-shaped trough has an angle of 60°, and is six feet long. A sphere 12 inches in diameter is placed in it and rolls throughout its length. How many revolutions does it make?

653. *Proposed by J. Carl Kamplain, Student, University of Chicago.*

Given a triangle ABC with $a = 6$, $b = 5$, $c = r$. Find a point P such that PA : PB : PC $= c : b : a$.

654. *Proposed by C. N. Mills, Heidelberg University, Tiffin, Ohio.*

Three circles, whose radii are r_1, r_2, r_3, touch one another externally. Show that one of the sides of the triangle made by joining the points of contact, is

(1) $$2r_1\left[\frac{r_2 r_3}{(r_1+r_2)(r_1+r_3)}\right]^{\frac{1}{2}};$$

(2) The area of the triangle formed by the points of contact is to the triangle formed by the centers of the circles as

$$2(r_1 r_2 r_3) : (r_1+r_2)(r_1+r_3)(r_2+r_3).$$

655. *Proposed by C. N. Mills.*

If a, b, c, the sides of a plane triangle, be in harmonic progression, show that

$$\left[\frac{\sin A/2}{\sin C/2}\right]^2 = \frac{\cos B - \cos A}{\cos C - \cos B}$$

SCIENCE QUESTIONS.

Conducted by Franklin T. Jones.

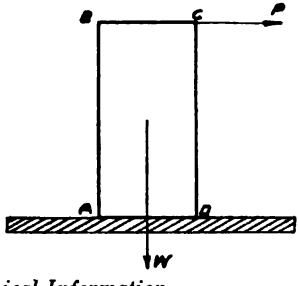
The Warner & Swasey Company, Cleveland, Ohio.

Readers are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, 10109 Wilbur Ave., Cleveland, Ohio.

QUESTIONS AND PROBLEMS FOR SOLUTION.

338. *Proposed by K. L. Pohlman, The Warner & Swasey Apprentice School, Cleveland, Ohio.*

Rectangle ABCD rests upon side AD. Side AD = ½AB. Coefficient of friction = ⅙ If it be pulled by a horizontal force P at C till motion ensues, determine if it will slip on the floor, or begin to turn over round D.



339. *Test VI. Technical Information.*

Will readers of SCHOOL SCIENCE AND MATHEMATICS *try this test upon*

Digitized by Google

themselves and send in the results? Answers will be treated confidentially.

(Please note that this test is copyrighted by Carnegie Institute of Technology.)

TEST VI, TECHNICAL INFORMATION, FOR COLLEGE FRESHMAN AND HIGH SCHOOL SENIORS.

(*Prepared for Society for the Promotion of Engineering Education, Committee No. 22 on Intelligence Tests.*)

(L. L. Thurstone, Division of Psychology, Carnegie Institute of Technology, Pittsburgh, Pa.)

Name.....
(Last Name) (Initials)

College..... Date.....

The object of this test is to determine how much technical information you have absorbed not only in school, but also in your activities outside of school.

Each question has four printed answers and you are to underline one of the four printed answers. Thus:

Electricity is conducted by
ropes wires twine yarn

Underline the word "wires" because that makes the truest statement. You will do likewise with all the statements in this test.

Do not write any other answers. Simply underline one, and only one, of the four printed answers.

Be sure to underline one of the four answers for each question even if you have to guess. Even if you do not know the answer you will make a guess. Try to guess the answer which looks to you the most reasonable even if you know very little about the question.

You are expected to finish this test. Take as much time as you reasonably need to answer all the questions. When you have answered all the questions, return this test to the examiner and leave the room quietly.

DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO BEGIN.

(Copyright 1919, by Carnegie Institute of Technology. Form S 1551.)

UNDERLINE ONE OF THE FOUR ANSWERS FOR EACH STATEMENT.

1. A magnet attracts
brass copper iron platinum
2. The rear hub of a bicycle is often fitted with a
coaster brake cyclometer grease cup tail light
3. An air rifle uses for ammunition
.22 short BB shot .32 center fire CB caps
4. Oil is ordinarily used as a lubricant when drilling holes in
cast iron steel wood brass
5. A common diaphragm opening for snap shots is
8 64 128 400
6. In making a core for an induction coil one ordinarily uses
mahogany rubber copper iron
7. Harley-Davidson is the name of a
motor cycle electric clock wireless detector aeroplane
8. The distributor in an automobile is a part of the
cooling system ignition system oiling system transmission
9. R. P. M. represents
volume speed content direction
10. In order to make solder adhere to metal surfaces it is necessary to use
oil flux glue gasolene
11. To keep the barrel of a target rifle in good condition one often uses
carborundum paste dutch cleanser vinegar three-in-one oil
12. Low voltage fuse wire ordinarily contains
lead silver brass platinum
13. The regulation Ford is equipped on the rear wheels with tires of a diameter of
2½" 3" 3½" 4"

Digitized by Google

14. The boiling point of water on the Fahrenheit scale is
212° 312° 512° 100°
15. A gas engine in which the explosion takes place in each cylinder once in every two revolutions of the shaft is called
one cycle two cycle three cycle four cycle
16. The material used for trolley wire is
galvanized iron aluminum copper brass
17. DeForest invented the
triple-valve vacuum-valve needle-valve safety-valve
18. What size wire is most commonly used for wiring a house for 110 volts?
6 8 14 20
19. The wrench to turn small sizes of gas pipe should be a
socket monkey Stilson box
20. Broaches are used in a
lathe boring mill drill press arbor press
21. What is the approximate daylight limit in miles radius of a quarter kilowatt spark gap wireless telegraph sending set?
one mile 10 miles 200 miles 1000 miles
22. The motion of the table of a planer in a machine shop is
rotary reciprocating continuous endless
23. Bricks are made of
clay granite sandstone gneiss
24. The gears used on a lathe for thread cutting are known as
helical bevel spur worm
25. The current obtained from dry cells is
rotary interrupted direct alternating
26. The purpose of back gears on a lathe is to
increase the speed cut threads turn tapers decrease speed
27. Balloons are filled with
compressed air hydrogen oxygen steam
28. Circles which pass through the North and South poles are called
equator latitude longitude equinox
29. Board measure pertains to
lumber cardboard paper metal
30. A file may be made to "bite" into cast iron by using
vaseline tallow beeswax chalk
31. The top of a shop bench is often made of
Douglas fir mahogany walnut maple
32. A split pulley on a shaft is held fast by
cement solder friction glue
33. A fillet in pattern making is ordinarily made of
leather wire twine sand
34. A bearing for a steel shaft, to wear well, is sometimes made of
cast iron bronze tool steel zinc
35. A file is held square across the blade and level in filing a
cross-cut saw rip saw back saw coping saw
36. A turret lathe is used in machining
bolts nails hammers scissors
37. Which of the following terms indicates gages of electric wires?
Winchester Roebling Brown and Sharpe Westinghouse
38. The chips made by a lathe in turning metals are long spirals when turning
cast iron steel aluminum zinc
39. In ordinary pattern work patterns are made of
fiber rubber leather wood
40. Pica is a term used in
navigation printing artillery railroading
41. The diameter of a Ford piston is
2½" 3½" 4" 4½"
42. Locks are manufactured by
Corbin Maydole Starrett Brown & Sharpe
43. Which instrument is used to measure temperature?
dynamometer condenser pyrometer rheostat

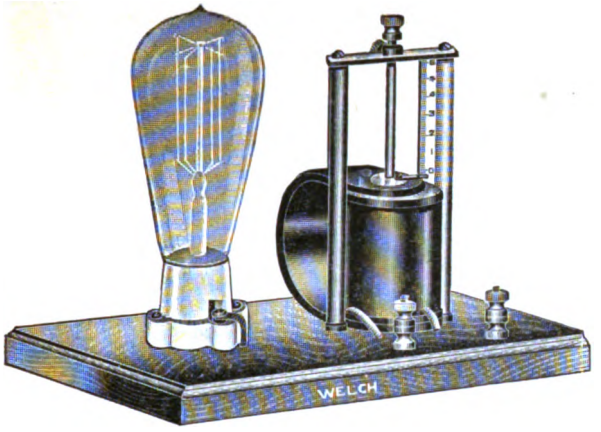
Digitized by Google

44. A file is made of
Bessemer steel machinery steel cold rolled steel high carbon steel
45. The number of leveling screws on an ordinary transit for surveying work is
2 3 4 6
46. A soldering iron is made of
iron steel copper tin
47. How many legs are there in the tripod of an ordinary surveying transit?
one two three four
48. If you had to make a strong bolt but could not get steel to make it of, your next choice would be
cast iron lead wrought iron brass
49. The blade is ground on the upper side in a
smooth plane block plane rabbet plane jack plane
50. Which of these screws requires a counter sunk hole?
fillister head round head hexagon head flat head
51. Which of these taps has the largest diameter?
⅜″ pipe tap ½″ U. S. Std. tap ½″ S. A. E. tap ½″ pulley tap
52. The contours on a topographic map indicate
roads elevation streams longitude
53. Edge tools and cutlery are made of
cold rolled steel wrought iron carbon steel cast iron
54. To whet a plane blade one should use
emery cloth a file sand paper an oil stone
55. The width of a standard gage railroad track is
4 feet 4 feet 8½ in. 5 feet 5 feet 6 in.
56. Shellac varnish is thinned by
distilled water alcohol turpentine gasoline
57. Shafting is sometimes made on the
planer miller shaper lathe
58. What material is used in making the insulation of common bell or annunciator wire?
wool rubber cotton silk
59. Ordinary concrete contains
asphalt cement glass rubber
60. An automobile cylinder should be finished to a very smooth even surface. This is sometimes done by
lapping milling filing turning
61. Aeroplane motor frames are sometimes made of
brass copper steel cast iron
62. Incandescent lamps in houses are ordinarily wired in
tandem multiple series
63. A good fabric for aeroplane wings is
wool cotton linen canvas
64. A star wheel is used in a
motion picture machine sewing machine steam engine bicycle
65. The split nut on a lathe is used for
reducing speed reversing speed driving carriage increasing speed
66. A window sash holds the
jambs casings glass sills
67. The L. S. Starrett Co. manufactures
tools soap furniture automobiles
68. Small angles are measured on an ordinary surveying transit by a
vernier capstan tripod leveling screw
69. A connecting rod bearing is sometimes made of
aluminum steel bronze cast iron
70. One part of the door is the
jamb head sill panel

Digitized by Google

71. A man six feet tall is best fitted with a diamond frame bicycle when the frame measures
15″ 18″ 24″ 36″
72. In sawing off a 10″ board one uses a
cross-cut saw rip saw coping saw turning saw
73. A cotter pin is ordinarily used to hold in place a
nut side curtain spare tire spark plug
74. The joints in most picture frames are
dovetailed mortise and tenon butted mitered
75. The current used by a two-phase motor is
D. C. static A. C. storage battery
76. Ordinary house paint contains
oil water alcohol gasoline
77. The spark plug on a gasoline engine is located on the
crank case cylinder manifold carburetor
78. In boring a small hole one sometimes uses a
mitre brace and bit T-bevel spoke shave
79. A gauge point on a carpenter's gauge should extend about
1-16″ ½″ 7-8″ 1½″
80. What is the standard commercial wave length for ships?
200 600 900 1200
81. A mallet should be made of
white pine cypress bass wood beech
82. Which of these cars have air cooled engines?
Packard Dodge Franklin Ford
83. Hot glue is thinned with
water turpentine alcohol linseed oil
84. The best resistance wire for electrical circuits is
silver copper German silver platinum
85. The joists in a building support the
roof foundations chimney floor
86. Which of the following metals can be case-hardened?
wrought iron aluminum copper babbitt
87. A frame building is constructed mainly of
brick wood steel tile
88. To keep a motor commutator clean use
oil sand paper emery cloth file
89. Shingles are nailed to the
joists sheathing jambs sills
90. Machine screws come in numbered sizes No. 1 to No. 30. Which is the smallest of these?
No. 6 No. 20 No. 12 No. 24
91. The uprights of a frame building are called
rafters lintels joists studding
92. Lead plate storage batteries are ordinarily filled with a dilute solution of
hydrochloric acid acetic acid sulphuric acid nitric acid
93. When gluing two pieces of wood together the surfaces should be
shellaced painted stained straightened
94. The cheapest heating system to install in a house is
steam hot water electric warm air
95. In cabinet work one most frequently uses
oak hickory catalpa cypress
96. The volt is a measure of
current pressure resistance power
97. A roof which has the shape of a four-sided pyramid is called
gable gambrel mansard hip
98. Small twist drills come in numbered sizes from No. 1 to No. 60. Which is the largest of these?
No. 52 No. 12 No. 21 No. 36
99. Those parts of a staircase into which the treads and risers are framed are called
stringers spandrels newels brackets
100. Auger bits increase in size in steps of
1-16″ 1-8″ 1-4″ 1-64″

Digitized by Google



QUALITY WELCH SERVICE

2601-CHOKE COIL This is a newly designed instrument which illustrates one of the most fundamental pinciples of electricity. It consists of a coil of many turns of wire connected in series with an incandescent lamp. The coil is wound around an iron core and a U-shaped armature of iron completes the magnetic circuit. The iron core may be withdrawn from the coil and thus the magnetic circuit may be broken and the air gap lengthened and shortened at will. When this instrument is connected to alternating current the current is varied by withdrawing or inserting the core in the coil. This shows most effectively that the "equivalent resistance" of the coil depends on the arrangement of the magnetic circuit outside—there is no change of the length or size of wire as in an ordinary rheostat. Ohms law does not fully apply here and this apparatus shows this definitely, and demonstrates the existence of the quantity known as "impedance."

As a demonstration piece it may be used before a class and show this principle to all at the same time, since when the core is withdrawn or inserted the lamp grows alternately bright and dim.

As a student piece it presents a very valuable test for the student to make measurements on, and the current and voltage in this coil when the core is in different positions may be measured. This will enable the student to calculate the apparent resistance and he will find that resistance is not constant as *Ohms law only* would show. The instrument is provided with a scale on one side so that the student may know exactly the length of air gap existing in the core, and some very definite ideas may be gained as to choking effect of an alternating current.

When direct current is used this instrument does not show this effect and when comparing the use on direct current to the use of it with alternating current it shows very forcibly this quantity of "impedance." By far the greater part of the commercial work is with alternating current and an increasing number of texts are including the teaching of these principles. This instrument will fill this very important need. The entire instrument is about 20 cms. high mounted on a mahogany finished base about 15x20cms. Complete coil mounted as shown and with incandescent light. Very handsomely finished and durably made.

A mark of quality

QUALITY WELCH SERVICE

from a house of service

W. M. Welch Scientific Company

Manufacturers, Importers and Exporters of Scientific Apparatus

1516 Orleans Street Chicago, Ill. U. S. A.

Digitized by Google

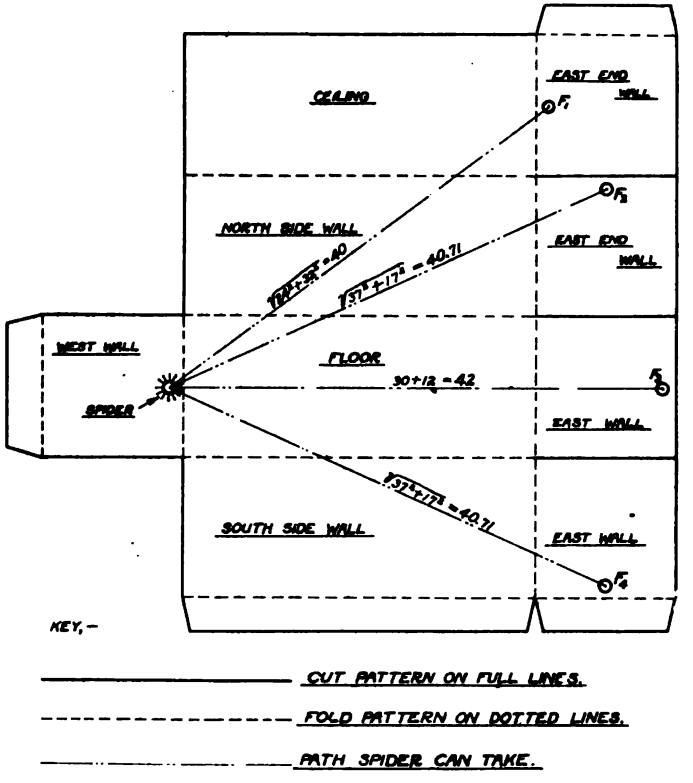
SOLUTIONS AND ANSWERS.

336. *Proposed by Worcester R. Warner to the boys in The Warner & Swasey Co. Apprentice School.*

A room is 30 feet long, 12 feet wide and 12 feet high. A spider starts from a point in the middle of the end wall of the room one foot from the floor and crawls to a fly in the middle of the opposite wall one foot from the ceiling. How far does the spider crawl if he goes by the shortest path?

Solutions from J. O. Hassler, Chicago, Ill.; E. W. Triess, Newark, N. J.; H. L. Caillet, Johnstown, Colorado; James C. Meeds, Sophomore Oakmont H. S., Oakmont, California; H. W. Corzine, Cleveland, Ohio.

The following pattern gives a complete solution of the problem, showing all the straight line paths the spider may use in approaching the fly. If the figure is cut and folded as directed—printing outside—the four F's will be found to coincide. The solutions will appear on the outside of the model.

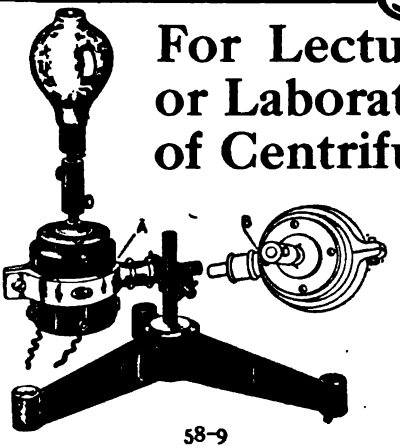


BOOK REVIEWS.

General Mathematics, by Raleigh Schooling, in charge of mathematics, The Lincoln School of Teachers of Teachers College, New York City, and Wm. D. Reeve, Teachers' Training Course in Mathematics in the College of Education, and Head of the Department of Mathematics in the University High School, The University of Minnesota. Pages xvi +488. 13.5×19 cm. $1.48. 1919. Ginn and Company, Boston.

The preface and introduction should be reprinted here since they present such a clear and convincing argument for a thorough reorganization of the course in secondary mathematics. The authors are especially well

Digitized by Google



For Lecture Demonstration, or Laboratory Application, of Centrifugal Force . . . . .

58-9

The Waverley-Electric Specifications

Support—Standard Tripod.
Yoke—Cast Aluminum.
Housing—Enameled Iron.
Motor—6,000 R. P. M.
Mica Insulation. Self-Adjusting Brushes. Ball-Bearing Shaft.
Current—D. C., A. C., or Dry Cells.
Chuck—Universal.

You Need This Waverley Electric—
A Whirling Machine and Centrifuge Combined.

As a whirling machine the Waverley-Electric takes a Centrifugal Globe (as illustrated), or Double Hoops, Centrifugal Balls, and other accessories.

A Centrifuge Head converts the Waverley-Electric into a powerful centrifuge that may be used with efficacy for the analysis of milk, urine, blood, or other liquids.

The specially designed, ball-bearing motor is mounted and balanced to operate in vertical or horizontal position. Consequently its general utility includes the rotation of Savart's Wheels, Siren Discs, Newton's Color Discs and the like.

58-9 The Waverley-Electric, including Support, Yoke, Motor and Chuck.....$19.00
58-9a Waverley Centrifuge Head, four-arm.. 3.75

Cambridge Botanical Supply Company
LABORATORY EQUIPMENT—ALL SCIENCES
1-9 Lexington Street 1884-1920 Waverley, Mass.

EDUCATION

40th year Sept. 1919. $3 a year. Sample 20c.
120 Boylston St., Boston, Mass.
"AS NECESSARY TO A TEACHER AS A MEDICAL JOURNAL TO A PHYSICIAN"

fitted by long study and successful classroom experience to produce a book which has for its purpose, "To obtain a vital, modern scholarly course in introductory mathematics that may serve to give such a careful training in quantitative thinking and expression as well-informed citizens of a democracy should possess," though with due modesty they say that their achievements are not the measure of their desires to improve the situation.

The material of this book consists of the simple and useful principles of arithmetic, algebra, geometry, practical drawing, and statistics, and emphasis is placed on function, equation, graph, and formula. The problem method of teaching is followed and the treatment is simple and easy for any teacher to use with satisfaction. Those who are interested in introducing a course in revitalized mathematics should certainly examine this book. H. E. C.

Modern Junior Mathematics, Books I and II, by Marie Gugle, Assistant Superintendent of Schools, Columbus, Ohio. Pages ix+222, xiv+239. 13×19cm. 1920. The Gregg Publishing Company, New York.

Book I is planned for a year's work in the seventh grade, or the first year of the junior high school, and aims to train the pupil in that part of arithmetic used in everyday business which he can understand, to develop skill in rapid calculation, to develop the habit of checking results, to develop habits of thrift, and to train the pupil in the simplest elements

Digitized by Google

of bookkeeping. The problem material and methods are taken as far as possible from actual business practice and will do much to train boys to become good business men and girls to become thrifty housekeepers. The method of presentation is admirable. First the use of a topic is shown then a feeling of need is created as a motive for learning and after this the topic is developed in a natural way with applications and practice to give the pupil a sense of really knowing the subject.

Book II covers a year's work in the eighth grade. Based on the mensuration and construction of plane figures it is planned to extend the pupil's knowledge of arithmetic, to train the hand to use the simple drawing instruments, to train the pupil to see geometric forms in nature and in buildings and other structures and to appreciate their use in design, and to introduce general number in a natural way that will give algebraic expressions a real meaning to the pupil so that he will use them readily as convenient and practical tools. The necessary equipment for the department and for each pupil is indicated. The work is well planned so that the pupil may advance slowly by doing and thinking for himself. It is certain that this series of books will be deservedly appreciated and widely used. H. E. C.

Plane Geometry, by Mabel Sykes, Instructor in Mathematics, Bowen High School, Chicago, and Clarence E. Comstock, Professor of Mathematics, Bradley Polytechnic Institute. Pages xii+322. 14×20 cm. 1919. Rand McNally and Company, Chicago.

It has been stated that the object of geometry teaching is threefold: (1) That pupils may acquire a certain number of geometric facts; (2) That they may be able to apply their geometric knowledge to the solution of problems; (3) That they may get some training in sound reasoning and precision of statement. This book seems to place the emphasis on the third object. But the second object is attained, at least as far as geometric problems are concerned. The analytic method of attack is used throughout. In the proof of nearly all the theorems the first step is the analysis, and this is given in such detail that the pupils who study this book will be thoroughly trained to invent their own proofs.

Moreover, the work is arranged to throw emphasis on the important theorems and methods in order to make the analysis effective. Hence the division into chapters is based on the important general ideas in geometry, congruence, ratio, area, similarity, and so on. There is an abundance of exercises, some with concrete setting taken from surveying, physics, architecture, and industrial design. The book was written "with the firm conviction that it is possible to give high school young people a more systematic training in the science of geometry than is furnished by any textbook on the market today." In the choice of type and paper, the uncrowded appearance of the pages, and all the details that go to the production of an attractive book, the publishers have added to the excellence of the work of the authors. H. E. C.

Intermediate Text Book of Chemistry, by Alexander Smith, Head of Department of Chemistry, Columbia University. 1st edition. Pages vi+520. 3.2×14.4×20.9 cm. Diagrams, graphs and several full page illustrations. Cloth. 1919. $2.25. The Century Co.

This new chemistry text, as its name implies, is intended to be used especially by those students who need some foundation in the general facts and principles of inorganic chemistry for subsequent use in domestic science, agriculture, etc., but who do not intend to follow chemistry intensively. The applications of chemistry are given more attention than in the more complete college texts of the same author.

Digitized by Google

Nearly Ready

Millikan and Gale's Practical Physics

Being a revision of Millikan and Gale's "First Course in Physics," made in collaboration with Willard R. Pyle, Morris High School, New York City.

Thoroughly modern and up to date "Practical Physics" embodies the most notable advances in physics. The authors are well fitted for the task of writing this particular text, for they held responsible positions in the scientific service of the government during the war, which gave them an insight into the latest practical applications of the science.

Practical application to the everyday life of the pupil is a distinct feature.

The text is profusely illustrated. Especially notable is the section dealing with the automobile.

GINN & COMPANY Boston New York Chicago London Atlanta Dallas Columbus San Francisco

THE AMERICAN MATHEMATICAL MONTHLY

OFFICIAL JOURNAL OF

The Mathematical Association of America

Is the Only Journal of Collegiate Grade in the Mathematical Field in This Country

This means that its mathematical contributions can be read and understood by those who have not specialized in mathematics beyond the Calculus.

The Historical Papers, which are numerous and of high grade, are based upon original research.

The Questions and Discussions, which are timely and interesting, cover a wide variety of topics.

Surveys of the contents of recent books and periodicals constitute a valuable guide to current mathematical literature.

The "Topics for Undergraduate Mathematical Clubs" have excited wide interest both in this country and in Great Britain.

The Notes and News cover a wide range of interest and information, both in this country and in foreign countries.

The Problems and Solutions hold the attention and activity of a large number of persons who are lovers of mathematics for its own sake.

There are other journals suited to the Secondary field, and there are still others of technical scientific character in the University field; but the monthly is the only journal of Collegiate grade in America suited to the needs of the non-specialist in mathematics.

Send for circular showing the articles published in the last six volumes.

Sample copy and all information may be obtained from the

SECRETARY OF THE ASSOCIATION

27 King Street **OBERLIN, OHIO**

Digitized by Google

Among the points that differentiate this text from its predecessors we note, first, that more attention is given to simple organic chemistry (chapters xvii, xviii and xix, chapters xxxii and xxxiii and chapter xxxvii); second, in chapters xxxi and xliii, we have an outline of qualitative analysis under the headings "The Recognition of Substances, a Review of the Non-metallic Elements" and "Recognition of Substances, II Metallic Elements."

Among the topics treated in the organic chapters are Fats, Soaps and Related Compounds, Explosives and Plastics, Plants, Fuels and Foods, and Agriculture. With the exception of this leaning toward a fuller treatment of applications of chemistry the text resembles in most respects the excellent series of inorganic chemistries of which it forms the latest member. F. B. W.

MEETING OF ASSOCIATION OF TEACHERS OF SECONDARY MATHEMATICS IN NORTH CAROLINA.

On January 30 and 31, the annual meeting of the Association of Teachers of Secondary Mathematics in North Carolina was held at the North Carolina College for Women, Greensboro, N. C.

The women who were in attendance were entertained while in Greensboro by the college. More than forty teachers were present. On the afternoon of January 30, the college gave an informal tea in honor of the Association.

Mr. W. W. Rankin, professor of mathematics, University of N. C., who is the executive Secretary of the Association, is on a year's leave of absence for graduate work at Columbia University. His absence necessitated double work for the President, Miss Cora Strong, of the N. C. College for Women, in planning the program and in making other arrangements for the meeting.

Professor L. C. Karpinski of the University of Michigan was the distinguished speaker invited to address the Association. On Friday evening he made his first address, an illustrated lecture on "The History of Algebra." This meeting was open to all the college students of the city and also to the students of the near by colleges. His second lecture, "The Methods and Aims in the Study of Mathematics," was given on Saturday morning. On Saturday afternoon he spoke on "The Practical Applications of High School Mathematics." He made the teachers realize how intensely alive and useful their science is, showing how the plan of a large auditorium, the reflector of an automobile, the arch of Hell Gate Bridge, the path of a projectile and the orbit of a comet are all reflections of an algebraic equation, and how the price of a railroad ticket may really be said to depend upon the binomial theorem.

Miss Irene Templeton gave a summary of the recent preliminary report of the National Committee on Mathematical Requirements on the "Reorganization of the First Courses in Secondary School Mathematics." A committee was appointed to get the consensus of opinion of the teachers of secondary mathematics in North Carolina and communicate with Professor J. W. Young, chairman of the National Committee.

The following officers were elected for the year 1920: President, Mr. A. W. Hobbs, University of North Carolina; First Vice President, Mr. T. C. Amick, Elon College, Elon, N. C.; Second Vice President, Miss Fannie B. Robertson, Fayetteville High School, Fayetteville, N. C.; Recording Secretary, Miss Birdie McKinney, Teachers Training School, Greenville, N. C.; Permanent Secretary, Mr. W. W. Rankin, University of N. C.—Maria D. Graham, Recording Secretary, 1919.

Digitized by Google

Blakiston

Now Ready

"Physics"

By Willis E. Tower, Englewood High School, Chicago; Charles H. Smith, Hyde Park High School, Chicago; Charles M. Turton, Bowen High School, Chicago; In Collaboration with Thomas D. Cope, Assistant Professor of Physics, University of Pennsylvania.

With 455 Illustrations, Including 7 Plates

Cloth, $1.35 Postpaid

The student finds in his teacher a guide to stimulate, to direct and to aid his efforts, and a critic to point out wherein his efforts have failed and wherein they have succeeded. Weights, measures and other apparatus are furnished enabling him to answer questions that have arisen in his studies. But, in addition to this, the student has his textbook—his teacher during the private hours of study. A good textbook is an inspiring teacher in print.

Five years of experience in teaching this text have proved the firmness of the foundation upon which it was built.

The present work is based upon and is in a sense a revision of "Principles of Physics" to which Professor Cope has brought the point of view of the university teacher who has seen the results of high school instruction with thousands of college freshmen.

P. BLAKISTON'S SON & CO. PUBLISHERS PHILADELPHIA

Digitized by Google

THE NATIONAL COUNCIL OF MATHEMATICS TEACHERS.

A new organization which promises much for the teaching of mathematics in the high schools of the country was launched February 24, in Cleveland, Ohio, in conjunction with the meeting of the Department of Superintendence of the N. E. A. The organization is called The National Council of Teachers of Mathematics.

The meeting was held in the Hotel Hollenden, Alfred Davis, of the Soldan High School, St. Louis, was elected secretary. Mr. J. A. Foberg of Chicago presided at the forenoon session, while Mr. D. W. Werremeyer, of Cleveland, presided at the afternoon session.

The following items were of especial interest in the program

"The Claims of Mathematics as a Factor in Education," by Professor C. N. Moore, of the University of Cincinnati.

Report of the National Committee on Mathematical Requirements, by Professor J. W. Young, of Dartmouth College. A discussion of this report was led by E. R. Smith, Principal of the Park School, Baltimore; and by Frank C. Touton, High School Inspector for Wisconsin.

"Mathematics of the Junior High School," by William Betz, of the Lincoln School, New York City. A discussion of this paper was led by Miss Marie Gugle, Assistant Superintendent of Schools, Columbus, Ohio.

Commissioner P. P. Claxton, of Washington, D. C., gave a brief address at the afternoon session.

Much enthusiasm was manifested by all who were present. It was a red letter day for the teaching of mathematics.

The committee appointed to consider the establishing of an official journal made the following report which was adopted:

"Your committee submits the following recommendations with reference to an official journal.

"1. Some official organ or journal is indispensable to the work of the National Council of Mathematics Teachers.

"2. It seems highly preferable that no new journal be launched by the Council.

"3. The journal shall be administered by an editorial board of from three to five members and an editor-in-chief. The members of the board shall be teachers of elementary and secondary mathematics, except one member who shall be an advisory member representing the college group.

"4. The appointment of the editorial board shall be vested in the Executive Committee of the Council.

"5. Your committee has been unable to negotiate in any detail-way with existing journals.

"J. R. Clark, Chairman, William Betz, D. W. Werremeyer, Charles Ammerman, W. D. Reeve."

The Constitution for the National Council of Mathematics Teachers:

I. NAME.

This organization shall be known as the National Council of Teachers of Mathematics—those who are primarily interested in elementary and secondary mathematics.

II. OBJECTS.

The purposes of this organization shall be:

1. To secure a greater degree of cooperation and solidarity among the teachers of mathematics.

(a) To provide for wide publicity of important reports and addresses related to mathematics and the teaching of mathematics, through an official organ and other publications.

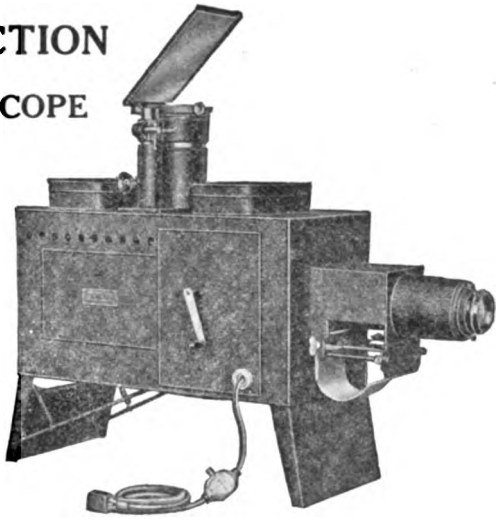
Digitized by Google

VISUAL INSTRUCTION
WITH
SPENCER DELINEASCOPE MODEL 3

is made perfect because it is an IDEAL STEREOPTICON for both lantern slides and opaque objects, such as pictures, post-cards, reading matter and objects of all kinds dead and alive.

IDEAL, because it embodies basic ideas (patented) possessed by no other. Example: Mechanical means of handling the slides, which does away with the antiquated lantern-slide holder and at the same time gives a "dissolving effect" on the screen unattained with other outfits except by using two stereopticons, one above the other.

One Spencer Delineascope does it.



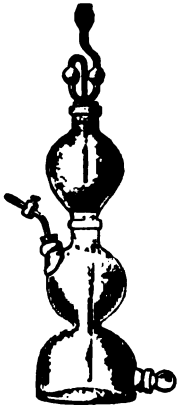
Spencers Delineascope Model 3 for both lantern slides and opaque objects. 1,000 Watt Mazda bulb illuminant.
Price, $185.00

SPENCER BUFFALO U.S.A.

SPENCER LENS COMPANY
Buffalo, New York

Manufacturers of **Microscopes, Microtomes, Delineascopes, Optical Glass, Scientific Apparatus, Etc.**

SPENCER BUFFALO U.S.A.



No. 2402

We Carry a Complete Stock of

Chemicals & Apparatus

for the

Physical

Agricultural

Chemical

Biological

Laboratory

We Excel in Equipping High School Laboratories.
Let Us Quote Prices on Your Next List of Requirements.

THE KAUFFMAN-LATTIMER CO.

41 East Chestnut Street
Columbus, Ohio

Digitized by Google

(b) To vitalize and coordinate the work of the many organizations of mathematics teachers throughout the country.

2. To bring the interests of mathematics to the attention and consideration of the educational world.

III. Time and Place of Meeting.

Regular meetings of the Council shall be held annually in connection with the meeting of the Department of Superintendence of the National Education Association.

IV. Membership.

Membership in the Council shall be of two kinds: individual and collective.

All persons who are in sympathy with the work of the Council shall be eligible to individual membership.

All organizations of mathematics teachers shall be eligible to collective membership.

The annual dues of individual members shall be

The minimum dues for collective membership shall be three dollars for each organization of less than fifty. For each additional hundred members, or fraction thereof, the dues shall be an additional five dollars.

V. Management of the Council.

1. Officers.

The officers of the Council shall be a President, a Vice President, and a Secretary-Treasurer. Their duties shall be those commonly pertaining to these offices. The President and Vice President shall be elected for a term of one year. The Secretary-Treasurer shall be elected for a term of three years.

2. Executive Committee.

There shall be an Executive Committee of nine members, three of whom shall be the officers. The remaining six shall be elected, two each year, to hold office for a term of three years; except that at the first meeting, two shall be elected for one year, two for two years, and two for three years.

The Executive Committee shall manage the business of the Council, authorize the appointment of committees, and fill vacancies in office.

3. Nominations.

At each annual meeting the President shall appoint a nominating committee of three members who shall report nominations for officers and for members of the executive committee.

VI. Amendments.

This constitution may be amended by a two-thirds vote of the members present at any regular meeting.

H. O. Rugg, Chairman, E. R. Smith, O. M. Austin, Marie Gugle, J. A. Foberg.

Officers elected: President, O. M. Austin, Oak Park, Ill.; Vice President, H. O. Rugg, New York City, N. Y.; Secretary-Treasurer, J. A. Foberg, Chicago, Ill.; Executive Committee: For three years, E. Marie Gugle Columbus, Ohio; Johnathan Rorer, Philadelphia, Pa.; for two years, Harry Wheeler, Worcester, Mass.; for one year, W. D. Reeve, Minneapolis, Minn.

ALFRED DAVIS,
Secretary of the Cleveland Meeting.

Digitized by Google

373.1
S37
S4

Vol. XX. No. 5 Whole No. 169

MAY, 1920

SCHOOL SCIENCE AND MATHEMATICS

A Journal for All Science and Mathematics Teachers

Founded by C. E. Linebarger

SMITH & TURTON, Publishers

Publication Office, Mount Morris, Illinois

CHICAGO OFFICE, 2059 East 72nd Place, CHICAGO, ILL.

CHARLES H. SMITH
EDITOR
Hyde Park High School, Chicago

CHARLES M. TURTON
BUSINESS MANAGER
Bowen High School, Chicago

DEPARTMENTAL EDITORS

Agriculture—Aretas W. Nolan
The University of Illinois, Urbana, Ill.

Astronomy—George W. Myers
The University of Chicago

Biology, Research in—Homer C. Sampson
The Ohio State University, Columbus

Botany—Wonolo Whitney
Hyde Park High School, Chicago

Chemistry—Frank B. Wade
Shortridge High School, Indianapolis, Ind.

Chemistry, Research in—B. S. Hopkins
The University of Illinois, Urbana, Ill.

Earth Science—William M. Gregory
Normal Training School, Cleveland, Ohio

General Science—Fredric D. Barber
State Normal University, Normal, Ill.

Mathematics—Herbert E. Cobb
Lewis Institute, Chicago

Mathematics Problems—Joseph A. Nyberg
Hyde Park High School, Chicago

Physics—Willis E. Tower
Englewood High School, Chicago

Physics, Research in—Homer L. Dodge
The State University of Oklahoma, at Norman. Representing American Physical Society

Science Questions—Franklin T. Jones
Warner and Swasey Co., Cleveland, Ohio

Zoology—Harold B. Shinn
Schurz High School Chicago

Published Monthly October to June, Inclusive, at Mount Morris, Illinois
Price, $2.50 Per Year; 30 Cents Per Copy

Entered as second-class matter March 1, 1913, at the Post Office at Mount Morris, Illinois, under the Act of March 3, 1879

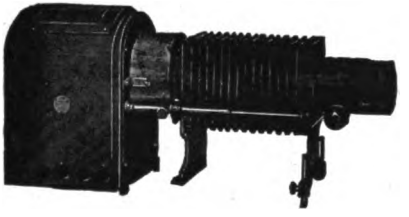
Digitized by Google

"McIntosh Lanterns Are Honest Lanterns."

Lantern Slides of Science

A copy of our Catalogs of science slides was mailed when published to every member of the Central Association. Are you a member? Did you get your copy? Did you keep it?

If not, there is another copy for you if you are interested. Just write us a card and ask for it. No obligation. You'll need it in placing your orders for science slides.



Lanterns from $13.00 up.
Opaque and micro projectors, slides and accessories.

McINTOSH STEREOPTICON COMPANY
410 Atlas Block, CHICAGO, ILL.

For Next Year

Vivian—EVERYDAY CHEMISTRY
—Just Published

Moore and Halligan—PLANT PRODUCTION
—Agronomy and Horticulture

Mayne and Hatch—HIGH SCHOOL AGRICULTURE
—General Treatment

Hunter—CIVIC BIOLOGY
—Community Welfare

Dryer—HIGH SCHOOL GEOGRAPHY
—Physical—Economic—Regional

Clark—INTRODUCTION TO SCIENCE
—A real general science.

New York
Chicago
Cincinnati
Boston
Atlanta

AMERICAN BOOK COMPANY
330 East Twenty-second Street
CHICAGO, ILLINOIS

Digitized by Google

SCHOOL SCIENCE AND MATHEMATICS

VOL. XX, NO. 5 MAY, 1920 WHOLE NO. 169

BIRD STUDY IN THE MISSISSIPPI VALLEY.[1]

BY HORACE GUNTHORP,

Washburn College, Topeka, Kans.

For this discussion I wish to divide the subject into two headings, the first being a statistical study of the membership of the three principal bird societies of the United States, and the second, a discussion of the number of bird courses given in the colleges and universities of this region—the Mississippi Valley. At first thought these subjects may appear either not at all or only remotely related to each other, but I hope to make the interrelationship clear as I proceed.

BIRD SOCIETY MEMBERSHIP.

The following table of membership in the three principal ornithological societies is compiled from the latest published lists of members, all of which appeared last spring (1919), and includes all classes of members in each case.[2]

Membership in Ornithological Societies.

	A. O. U.	Cooper	Wilson	Total
Eastern States:				
Maine (2)	17	1	0	18
New Hampshire	11	0	1	12
Vermont (1)	8	1	0	9
Massachusetts (23)	204	40	13	257
Rhode Island	11	3	4	18
Connecticut (5)	34	13	10	57
New York (19)	123	33	23	179
Pennsylvania (7)	75	14	13	102
New Jersey (3)	37	9	7	53
Delaware	0	0	1	1
Maryland	10	2	1	13
West Virginia	3	0	1	4
Washington, D. C. (27)	63	29	11	103
Southern States				
Virginia	4	1	2	7

[1] Revised from paper read before The Wilson Ornithological Club, at St. Louis, Mo., Dec. 29, 1919.

[2] American Ornithologists' Union list from *The Auk*, Vol. 36, pp. XIII–XLV, April, 1919; Cooper Ornithological Club list from *The Condor*, Vol. 21, pp. 135–144, May, 1919; Wilson Ornithological Club list from *The Wilson Bulletin*, Vol. 31, pp. 29–40, March, 1919.

Digitized by Google

North Carolina	3	1	1	5
South Carolina (1)	7	1	1	9
Georgia	1	1	1	3
Florida (1)	3	3	2	8
Alabama	2	0	0	2
Mississippi	0	0	0	0
Louisiana	3	3	3	9
Texas (1)	5	6	3	14
Central States:				
Michigan (2)	16	6	18	40
Ohio (1)	21	8	41	70
Indiana (1)	9	3	13	25
Kentucky	1	0	0	1
Tennessee (1)	4	0	8	12
Wisconsin	11	0	7	18
Illinois (4)	48	21	66	135
Minnesota (1)	13	5	6	24
Iowa (1)	7	3	51	61
Missouri (2)	7	5	4	16
Arkansas	0	2	1	3
North Dakota	1	0	3	4
South Dakota	2	0	3	5
Nebraska (1)	5	6	48	59
Kansas	5	7	7	19
Oklahoma	1	1	0	2
Western States:				
Montana	2	2	0	4
Idaho	3	2	0	5
Wyoming	1	0	0	1
Colorado (2)	21	12	6	39
Utah	5	11	0	16
Nevada	1	4	0	5
Arizona	1	8	0	9
New Mexico	4	3	0	7
Washington (2)	11	18	3	32
Oregon (2)	9	13	0	22
California (16)	50	278	13	340
Alaska	2	1	1	4
Canada (4)	27	19	14	60

In the Wilson list, under Nebraska, are included forty-seven names of members of The Nebraska Ornithologists' Union, a society affiliated with the Wilson Ornithological Club. There is some duplication of names, as often a single person belongs to all three societies, but it is probably true that such an individual is worth three times as much to ornithology as the person who belongs to only one society. The present membership is undoubtedly somewhat larger than these figures show, as the study of ornithology has been taken up with renewed vigor since the close of the war, and a more or less energetic campaign has been carried on for members in the several societies. To illustrate the increase, I have a letter from Dr. T. S. Palmer, Secretary of the American Ornithologists' Union, in which he states that since the election last November, there are now twelve members in Kansas, whereas the table shows only five. However, even if these figures are somewhat out of date, the main

Digitized by Google

facts I wish to bring to your attention will still be illustrated by them, and as they are of equal age for the three societies, comparisons are possible.

It will be noticed at once that the Southern States are especially short of members. This may be due to several reasons, probably the largest one of which is general apathy on the part of the educated classes towards bird problems of the day. Certainly we have had few indications from the lawmaking bodies of the states in question to manifest that they are interested in bird protection, and they must reflect to a large degree the general condition. However, some valuable bird reports have come from Southern States, as those of North and South Carolina. Perhaps lack of members is due to the fact that no serious campaign for them has been carried on. If such is the case it can easily be remedied. The colleges and high schools make natural focal points for starting such a campaign, but those of the South are not as well organized, especially in the sciences, as they are in the North.

Both the East and West have heavy memberships, centered in the former region in Massachusetts and New York, and in the latter, in California. And both of these centers are carrying on active work of a high class.

Turning to our own territory, the Mississippi Valley, we find some States with a good number enrolled, as for example, Ohio Illinois, Iowa and Nebraska, but most of the remainder are a long way behind where they should be. And one of the strange facts is that we have one of the best territories for bird study on the continent, owing to the fact that we are on the migration route of so many species. Certainly right at home is our field for doing missionary work to convert more people into bird lovers and bird students, and to get them to express their interest by joining a bird society.

The American Ornithologists' Union has three classes of members, the lowest class being Associates, number unlimited, the second class being Members, limited to one hundred, and the highest class being called Fellows, of which there can be no more than fifty. Associates are elected to the higher classes for exceptional research in some branch of ornithology, so it is safe to presume the one hundred fifty names contained in the lists of Fellows and Members of the A. O. U. contain the most imminent bird men in the country. In the above table, the numbers in parentheses directly following the name of the state repre-

Digitized by Google

sents the total of Fellows and Members of the A. O. U. who reside therein, according to the published list. If we study this list of one hundred fifty names, we find their totals tally rather closely with the totals in the last column, representing the total memberships in all three societies, with the exception of the District of Columbia, this being due, of course, to the large number of scientists in Washington employed by the Government. They also seem to center around large museums, and this leads to the conclusion that the majority of them gained their standing through systematic work. Such has probably been the case in the past, but during recent years other lines of endeavor are beginning to take the place of systematic study.

It is probable that the close association of imminent ornithologists with the totals of membership in the three societies is due to the fact that when a man is especially interested in a subject he emanates enthusiasm to those around him, and they are much more liable to become interested in the same line of work. The interest of these men would also lead to a more virile campaign for members, and so an endless chain would be started.

The Central States have a total of fourteen names in the list of Fellows and Members of the A. O. U., Illinois leading with four. This is fair, but below what we should have. However, it is in proportion to our total memberships. I think the workers of this region often let outside ornithologists come in and do our good things for us. I know this is true of the North Dakota lake region, and other places. Or perhaps our best men leave us for fresh bird fields.

Courses in Ornithology.

Regarding the number of colleges and universities in the Mississippi Valley which give courses in ornithology, I find there are a total of about one hundred forty schools of this rank having over one hundred college students, and of these, thirty-four give such a course, one other (probably more) offers considerable bird study as part of another course in zoology, and one hundred five give no such work, so far as I am able to learn. In other words, approximately thirty per cent of the institutions give bird courses.

The following table gives in tabular form a few particulars regarding the courses given in the institutions offering ornithology. It is compiled almost entirely from information gained from a questionnaire sent to the teachers giving these courses,

Digitized by Google

or to the heads of the biology or zoology departments, when such instructors were unknown. The responses were prompt and full, and I wish to thank those who so kindly cooperated with me in this effort.

Institution	Courses given	Hours of credit	Semester fee	Laboratory
Baldwin-Wallace, O.	1	2	$1.00	Yes
Carthage, Ill.	1	2	3.00	Yes
Central, Mo.	1	2-3	None	Yes
Coe, Ia.	2	6	5.00	Yes
Doane, Nebr.	1	1	None	None
Drake, Ia.	1	5	1.00	Yes
Drury, Mo.	1	2-3	2.00	For extra hour
Earlham, Ind.	1	2	1.00	None
Eureka, Ill.	1	3	None	Yes
Fargo, N. Dak.	1	3	2.00	Yes
Hastings, Nebr.	1	3	2.00	Yes
Hillsdale, Mich.	1	2	1.00	Yes
Illinois	2	4-7	None	Not in elementary
Illinois Wesleyan	2	4	2.50	Yes
Illinois Woman's Col.	1	1	.50	None
Indiana	1	2	1.50	Yes
Iowa	2	6	None	Yes
Iowa Wesleyan	1	2	1.00	Yes
Kansas	1	3	1.50	Yes
Kentucky	1	3	None	Yes
Knox, Ill.	1	1	1.00	Yes
McPherson, Kans.	2	8	2.50	Yes
Mich. Agricultural Col.	1	5	1.00	Yes
Minnesota	2	4	None	Yes
Morningside, Ia.	1	4	2.00	Yes
Nebraska	1	1	2.00	Yes
Oberlin, Ohio	3	5-6	2.00	Yes
Ohio State	1	2	None	Yes
Ohio Wesleyan	1	2	1.00	Yes
Washburn, Kans.	1	2	1.00	None
Western Reserve, O.	1	3	5.00	Yes
Wilmington, Ohio[3]	1	2	None	
Wisconsin	1	2	1.50	Yes
Yankton, S. Dak.	1	3	Yes	Yes

There is considerable variation in the nature of the single elementary course given by most of the schools, some of them making it a popular study with no prerequisites, while in others it is an advanced course with a year of biology or zoology before it. Of one course of the former character, the instructor says: "Perhaps we should call it a bird club rather than a class." From this on the one hand, we pass to the more pretentious classes, and finally to those where a second course in ornithology is given. In most of the schools, the second course, is like the first, general in nature, but more advanced. In Illinois, the elementary course does not have laboratory, but the advanced does. In Minnesota, the first one has laboratory but no field

[3]From 1919 catalogue.

Digitized by Google

work, while the second is the reverse. In Oberlin the first two courses are general, but "The other spring course is entirely devoted to the study of current migration."

The number of semester hour credits given varies from one to five for a single course, and from four to eight for two or three courses. In the case of McPherson College, where eight may be obtained, "This course is by appointment and credit depends on amount and grade of work done."

Fees vary from none to $5 per course. The average for those given, not counting the ones where no fee is charged, is $1.83. The fee in connection with three or four hour courses should probably be somewhat higher than this, judging from the two following quotations, where the fee is $2: "Should be more to cover expense of skins and mounts injured and destroyed by students." "Fee should be higher, but students usually have to buy a field glass and one or two books, and we have hesitated about raising the fee." Where there is no fee at present, we hear that "We will add a fee next year," and "None this year. Think we should have a fee of at least $2." It looks as if the H. C. L. has hit bird courses as well as everything else!

Five of the colleges do not offer laboratory work with their bird courses. In the rest it varies considerably, according to material available and inclination of the instructor. Without exception, field trips are included in every course given. There is a great deal of variation as to how much of the time is put in in this way, but in most of the courses field work forms a substantial and important part. The early weeks of the course seem more likely to be devoted to laboratory and the latter ones to field work. The migration period and weather conditions have an important bearing on the time and proportion of each. Very often we find the statement that the class has either laboratory or field trips every week, the one taking the place of the other.

If the schools giving bird courses listed in the above table are arranged by States, it will be seen that Illinois and Ohio lead with six, while Iowa is a close third with five. If one refers back to the table of membership in the bird societies, it will be noted these same three States lead the Central group in total members, and in the order named. In fact, this relationship between the number of institutions giving courses in ornithology and the total membership in bird societies continues all down the line with remarkable regularity, as shown in the following table:

Digitized by Google

State	Colleges	Members	State	Colleges	Members
Illinois	6	135	Minnesota	1	24
Ohio	6	70	Wisconsin	1	18
Iowa	5	61	South Dakota	1	5
Nebraska	3	59	North Dakota	1	4
Kansas	3	19	Kentucky	1	1
Michigan	2	40	Tennessee	0	12
Indiana	2	25	Arkansas	0	3
Missouri	2	16	Oklahoma	0	2

If the sizes of the institutions concerned and the length of time the courses have been given are considered, I am sure the few irregularities in the above table could be accounted for. This parallelism leads one to the conclusion that there is a close relationship between courses in ornithology in our colleges and universities and the prosperity of our bird societies. Most students become interested in and enthusiastic about birds when studying them, and if their attention is called at the proper time to the work of the societies, a considerable proportion will join and keep up their membership. But we must have teachers who believe in bird societies themselves.

In this connection, it is interesting to note that the teachers of these thirty-four bird courses are as a rule not members of a bird society. In the lists of members of the three societies above referred to, we find the names of the instructors giving these courses appearing a total of twenty-four times, distributed as follows: A. O. U., ten; Cooper, five; Wilson, nine. But two persons belong to two societies, and five, to all three. This reduces the number of individuals belonging to twelve, or a little over one-third of the total number. The reason for this lack of interest probably comes under one of the following heads: First, it may be for financial reasons. If this is the case, it would be a good idea to join, and let the school pay the fee from its library fund and place the magazines as received in the library. If the course is worth giving, it is worth providing magazines for. Second, this lack of interest may be due to lack of knowledge of the existence of these societies. In my own case, I discovered it more or less by accident. There are very few mentions in bird literature of these societies and the work they are doing. Persons interested in their growth do not seem to realize the value of publicity. It cannot be done to any great extent through the magazines the societies themselves publish. A third reason is that a good many of the instructors are not interested in the investigation side of ornithology, and as a result they find little to interest them in the literature or magazines

Digitized by Google

published by the societies, as these seem too often to run to technical matter of interest to no one except the specialist. The Cooper Club seems to be meeting this situation to a certain extent, and a considerable portion of *The Condor* is really readable, with numerous pictures. The one other drawing card the societies have is their annual meetings. But it is only once in a while that a person is near enough to the place of meeting to be able to attend one of these, so, for most members, they are few and far between, and this advantage of membership is largely negative. The Wilson Club has wisely become affiliated with the American Association for the Advancement of Science, and as a result their annual meetings are held at the same time and place as the meetings of a large group of other scientific societies. This should add greatly to the attendance and interest in these gatherings, and make them well worth while. The Cooper Club has tried to solve this question by having monthly meetings in centers where there are enough members to warrant them. This combines features of both local and national bird societies, and seems to be working well.

The Mississippi Valley is the special territory of the Wilson Ornithological Club, and this society deserves our special support for this reason, if for no other. There are four classes of members, Honorary, Sustaining, Active, and Associate, and the membership (March, 1919) is 4, 18, 203 and 194 for the four classes respectively. The club publishes *The Wilson Bulletin*, a quarterly of from forty to fifty pages a number. This is now in its thirty-second volume, and is under the able editorship of Dr. Lynds Jones, of Oberlin. As mentioned above, the annual meetings are in conjunction with the meetings of the A. A. A. S., and for this reason should be comparatively easy to attend, especially for science teachers.

In conclusion, we need more members in our bird societies, and there are two places from which to draw them, either from the ranks of those who are already interested in the subject, or by making more bird lovers from which to draw. To reach persons at present interested in the subject is a problem that is up to the officers and members of the societies. That the surface has hardly been scratched is shown by the large per cent of teachers giving bird courses who are not members of any organization of national scope. This being so, a moments thought will lead one to conclude there must be even a larger per cent of laymen outside the membership rolls. In regard to making more

Digitized by Google

bird lovers, from the figures given above, certainly there is no better way than by giving courses on birds in our colleges and universities. A little knowledge in this case does not usually prove to be a dangerous thing, but, on the contrary, serves as leaven for a more intimate knowledge and growing interest as the years go by. And if such students can be interested in a bird society, it will help keep them in touch with the subject for the rest of their lives, and here and there among their number may be found a real bird student, the kind we must have to keep ornithology on a level with the other sciences.

PRODUCTION OF CADMIUM IN 1919.

The output of metallic cadmium in 1919 was 99,939 pounds, compared to 127,164 pounds in 1918 and 207,408 pounds in 1917, the maximum output in the history of the industry. The production of cadmium sulphide was 31,197 pounds, compared to 51,702 pounds in 1918. The combined value of metallic cadmium and cadmium sulphide in 1919 was about $160,000, compared to $258,518 in 1918 and $376,036 in 1917. These figures, computed by C. E. Siebenthal, are made public by the U. S. Geological Survey, Department of the Interior.

Though prices of cadmium were somewhat lower in 1919 than in the three years immediately preceding, the industry closed the year in better condition than in 1918, for the reason that the consumption practically reached the level established in 1916-17, and this with the decreased production operated to reduce stocks.

LIGHT FOR RETOUCHING.

An expert in retouching writes very sensibly in *The British Journal* as follows: "In the days when I did a good deal of retouching I found it best to avoid any arrangement which allowed any light, however diffused, to fall directly on the negative, as it was always very trying to the eyes, and I maintain that retouching ought not to produce eye-strain if the negative is properly illuminated. I have often retouched till long past midnight without getting my eyes tired. The arrangement I have always used, whether the source of light was paraffin-lamp, incandescent gas, electric or daylight, allowed no light to fall directly on the negative, but was all sent upward through the negative by reflection from a sheet of white paper, or if the negative was extremely dense a piece of matte sheet-aluminium was used instead.

"Eye-strain in retouching is caused by trying to see every stroke made by the pencil. I believe that it may be almost entirely avoided by working at such a distance that each touch is not seen but only the general effect, working just as an artist does when he 'stipples' in watercolor or miniature-painting.

"Many retouching-desks are not sufficiently upright; the slope of the desk should not be less than sixty degrees. This will be found more restful and healthy, and will not cause the worker to stoop. This was the angle of the desks used by the mediaeval writers, who spent their lives writing at a time when writing was a fine art. I often wonder that men who spend their days 'pen-pushing' do not use a desk with a steep slope, they would get far less indigestion and have straighter backs."—*Photo Era.*

Digitized by Google

RESEARCH IN CHEMISTRY.

Conducted by B. S. Hopkins.
University of Illinois, Urbana.

It will be the object of this department to present each month the very latest results of investigations in the pedagogy of chemistry, to bring to the teacher those new and progressive ideas which will enable him to keep abreast of the times. Suggestions and contributions should be sent to Dr. B. S. Hopkins, University of Illinois, Urbana, Ill.

THE POSITIVE ELECTRON AND THE BUILDING OF ATOMS.[1]

By William D. Harkins,
The University of Chicago.

The discovery of the negative electron may be said to be due to Sir William Crookes and to J. J. Thomson, though this form of electron was first definitely recognized by the latter. The mass of this electron is very small, and is only about 1-1835 of that of the hydrogen atom, the lightest of all atoms. The mass of any atom, as is well known, is almost altogether associated with its positively charged part, and not with the negative charge. While the idea that the positive part, or nucleus of the hydrogen atom, "*may* be the positive electron" is quite a common one, there was evidence that seemed conclusive, which was considered to show that this was probably not the case, the evidence being that the atomic weights of chlorine, magnesium, and silicon, and many other elements, are not at all nearly multiples of the atomic weight of hydrogen by a whole number.

In 1915 I developed a theory of atom building which gave a rational explanation of this apparent discrepancy, and showed with considerable conclusiveness that all of the other atoms are built up from hydrogen nuclei, which therefore are the positive electrons, and of negative electrons, the mass of the atom being due almost entirely to the former. Four positive unite with two negative electrons to form the nucleus of the next heavier atom, that of helium. This is the well known alpha ($\alpha++$) particle which is shot off at high speed from radioactive atoms when they disintegrate. These alpha particles are the most important constituents, from the standpoint of mass at least, in all of the heavier atoms. This theory soon led to the discovery of a new periodic system which is of great importance

[1]Abstract of a general address presented at the Philadelphia meeting of the American Chemical Society, September 3, 1919.

Digitized by Google

in connection with the evolution of the atoms, or what is commonly, but less correctly known as the evolution of the elements.

The New Periodic System of the Atoms.

What is usually known as the periodic system of the elements was developed largely in the decade from 1860 to 1870, during the period of our Civil War, by de Chancourtois, Newlands, Mendeléeff and Meyer. Mendeléeff, the third to develop the system, has been given almost all of the credit for it, but this is largely because he paid very much more attention to its details than any of the three others. It has now been found that the Mendeléeff periodic relation is simply one method of expressing the arrangement in space of the electrons in the outer part of the various kinds of atoms.

Five years ago I discovered a *new periodic system of the elements, or more properly speaking, of the atoms. This second system is not at all directly related to the arrangement of the electrons in the outer part of the atom, but has been found to indicate how the atoms are built up, that is, it is related to the structure of the nuclei of the different species of atoms.*

In order to understand the meaning of this new periodic system it is important to have a good idea of the present theory as to the general structure of the atom. According to Rutherford the atom is similar to the solar system in that it has a central sun called the nucleus of the atom, and a system of planets, each of which consists of one negative electron. The atom as a whole is electrically neutral, and the electrons outside the nucleus, which we may call the planetary electrons, are held in the atom by a positive charge on the nucleus. This positive charge is equal numerically to the sum of the charges of all of the planetary electrons. This is often expressed by the statement that the number of positive charges on the nucleus is equal to the number of negative electrons, since it is known that the hydrogen ion carries a positive charge equal to the negative charge on the negative electron.

The atom is similar to the solar system in a second sense, for the planetary electrons are, relative to their size, about as far from each other and from the nucleus, as the planets and the sun. Thus it need not be surprising from this point of view, that Rutherford has found that the very minute nucleus of a helium atom, often called the alpha particle, may be shot directly through many thousands of other atoms, without hitting a single nucleus

Digitized by Google

or a single negative electron, just as a planet like the earth might be shot through thousands of solar systems like our own without hitting a single sun or planet.

The atom is like the solar system too, in that the nucleus, like the sun, possesses nearly the entire mass of the system, since in general the nucleus is about two thousand times heavier than all of the electrons which surround it. While the atom is so small that a row of fifty million atoms would be only about one inch long, if they were put as closely together as they are in solids; and so small too, that there are 180 thousand billion billion atoms of carbon in one cubic centimeter of diamond; the atom is so *large* compared with the electron, that, if we take the dimensions usually accepted for the electron, there would be space in a single atom sufficient to contain ten million billion electrons, while the atom which contains the greatest number of planetary electrons, uranium, actually has only ninety-two of these. According to the work of Rutherford, Geiger, Darwin and Marsden, the nucleus of even the heaviest atom, is not very much larger than a negative electron. Thus the atom may be said to be very sparsely populated with electrons, or an electron in an atom occupies somewhat the same relative space as a fly in a cathedral.

The atom is *unlike* the solar system in that the planetary electrons are arranged more or less symmetrically in space around the nucleus, at least that is the idea expressed in papers by the American chemists, Parsons, Harkins, Lewis, and Langmuir.

Also, while the solar system is held together by the gravitational attraction between the large mass in the sun and the smaller masses in the planets, the atoms are held together by the positive electrical charges in the nucleus and the negative charges of the electrons, together with whatever magnetic effects are produced by the rotation of the electrons.

The Building of Atoms.

While chemists have not as yet synthesized any atoms, it is also true that they have only recently begun the study of their structure. Now, when a chemist wishes to build up even such a simple thing as an organic molecule, he first studies its structure, and often many years intervene between the working out of the structure of the molecule and its first synthesis. In the synthesis of an organic dye there may be two steps which we may have to consider. Suppose for example that the first of

Digitized by Google

these consists of a complex set of reactions which are very difficult to carry out, while the second step will occur by itself if the intermediate product is only left standing in the air. It is evident that the practical chemist will need to put almost his whole attention on the first step of the synthesis. The building of atoms is similar in that the first step, the building of the nucleus of an atom, has not yet been accomplished, while, if the nucleus were once built, it would of itself pick up the whole system of planetary electrons which would turn it into a complete atom. For example, in the disintegration of the nuclei of certain radioactive atoms, alpha particles, which are the nuclei of helium atoms, are shot out as rapidly as twenty thousand miles per second, so rapidly that they pass through as many as *half a million* other atoms before coming to comparative rest. Now Rutherford has proved that when these nuclei finally slow down, they give the ordinary spectrum of helium, which indicates that each alpha particle has picked up the two negative electrons which are essential to convert it into a complete helium atom.

The Building of the Nuclei of Complex Atoms.

Suppose that we consider the specific problem of the building of a carbon atom. The characteristic chemical and physical behavior of carbon is due to its six planetary negative electrons, and these will arrange themselves around any nucleus which carries a positive charge of six, so our problem reduces to that of putting six positive charges of electricity into the extremely minute space occupied by the nucleus of an atom, with a diameter of the order of 10^{-12} cm., that is one millionth of a millionth of a centimeter. These six positive charges must not only be put into this *ultra-ultra-microscopic* space, but must unite to form an intra-nuclear compound of extreme stability.

Now, up to the present time, the smallest mass ever found associated with one positive electrical charge is that of the hydrogen ion, which is associated primarily with the mass of the hydrogen nucleus, with a value of 1.0078.[2] If six of these hydrogen nuclei could be packed tightly enough together to form the nucleus of a new atom they would form the nucleus of a carbon atom, which would have a mass of approximately six. That no carbon atom of this mass exists is not because such a nucleus, if formed, would not give a true carbon atom, but because six positive hydrogen nuclei undoubtedly repel each other, and can not be made to form a stable system.

[2] Equal to 1.66×10^{-24} grams.

Digitized by Google

In order to make a complex nucleus stable it is necessary to include not only hydrogen nuclei, but also negative electrons. Since the mass of the ordinary carbon atom is 12.00, it could be built up from 12 hydrogen nuclei, bound together by six negative electrons. Such a nucleus would have a positive charge of 6, it would therefore take up six negative electrons, and would thus form a complete carbon atom. The only objection to this idea is that 12 times 1.0078 is 12.036, while the weight, and probably the mass, of the carbon atom is only 12.005, or the actual carbon atom is 0.76 per cent lighter than it would be if built from 12 hydrogen nuclei without any resulting change of mass. Now Professor A. C. Lunn has worked out the mathematical expression for this effect for the writer, and this shows that according to the electromagnetic theory, if such a nucleus is held together in a very small space by attractive forces there *should* be a loss of mass in its formation, and that in a simple atom the observed loss of mass would result if the center of the negative electron has a distance 400 times the radius of the positive electron.

The alpha particle, or the nucleus of a helium atom, carries two positive charges, has a mass of four, and is probably made up of four positive hydrogen nuclei bound together by two negative electrons into what is probably by far the most stable nucleus of any known atom, except that of hydrogen itself.

If we consider the atomic number[3] of the element to be equal to the positive charge on the nucleus, then the atomic number of hydrogen would be one, that of helium two, that of carbon six, of lead eighty-two, and of uranium, ninety-two. Now the mass of the carbon atom (atomic number 6) is exactly what it should be if its nucleus consists of 3 alpha particles. Also, 3 times the charge on the alpha particle is just the charge on the carbon nucleus. It is easily seen that there is a possibility that the carbon nucleus is simply a compound made up of 3 alpha particles, of a formula 3α. Now it is obvious that if the nuclei of complex atoms were simply structures built up from alpha particles, that, since the positive charge on the alpha particle is two, there would be no nuclei with an odd number of charges.

[3] The atomic number of an *element* is its number in the periodic system of Mendeleeff, and is equal to the number of net positive charges on the nucleus of an atom, that is the number of positive minus the number of negative electrons in the nucleus, and is also equal to the number of the planetary electrons. An element may consist of several kinds of atoms (isotopes) with different atomic weights, but all of the atoms of one element have the same number of positive charges on the nucleus, and the same number and the same arrangement of planetary electrons. Thus one element may consist of several species of atoms, all of which act alike chemically, but differ in mass and the structure of the nuclei.

Digitized by Google

The work of Moseley indicates, however, that the elements of odd atomic number also exist, but it is certain that the nuclei of such odd numbered atoms can not be compounds made of alpha particles alone.

On the other hand, it is quite evident, as I announced four years ago, that the nuclei of the atoms of even atomic number are mostly intra-nuclear compounds of helium nuclei. For this there is much evidence which will be found in my papers in the *Journal* of the American Chemical Society and in *Science*.

I wish to show just a little as to the way in which these alpha particles are bound together.

First, the atomic weights of the lighter atoms of *even* atomic number beginning with carbon are, 12, 16, 20, 24, 28, 32, 40, 40, 48, 52 and 56, the last being the atomic weight of iron, of atomic number 26[1]. Thus the atomic weights of the atoms whose nuclear charge is expressed by an even number are divisible by 4, the weight of the helium nucleus. If we study the elements of high atomic number, beginning with uranium, which is number 92, we find that the even numbered atoms change into the atom of next lower even number by the loss of a single alpha particle from the nucleus of the atom. Thus we find just the same system of structure indicated by the actual disintegration of the radioactive atoms as is made evident by the atomic weights and the nuclear charges on the atoms of low atomic weight.

Second, the atomic weights of the elements of odd atomic number point to the idea that their nuclei are compounds of a certain number of alpha particles with three hydrogen nuclei, so that their formula is $n\alpha+3h$. In the exceptional cases of nitrogen the formula is $3\alpha+2h+\epsilon$.

Four years ago I presented the following formula for the respective nuclei:

Carbon nucleus $= 3\alpha$
Nitrogen nucleus $= 3\alpha+2h+\epsilon$
Oxygen nucleus $= 4\alpha$

where ϵ represents a negative electron.

It is of extreme interest in this connection to note that Sir Ernest Rutherford has just announced that he has been able to bombard these atoms with extremely rapid moving alpha

[1]It is of extreme interest to note that the mass of the alpha particle is 4.00, and that its positive charge is 2 and that also the mass of the nucleus of the complex atoms is found to increase by 4.00 whenever the positive charge increases by 2.

Digitized by Google

particles, and that he has been able to drive hydrogen out of nitrogen atoms, but not out of either carbon or oxygen.

The plan according to which the nuclei of the lighter atoms of even numbered nuclear charge are built up, is so simple that it might easily be made the subject of oral problems in arithmetic for the elementary schools. Thus knowing that these complex nuclei are made up from alpha particles alone, and that each alpha particle weighs 4.0 and has a positive electrical charge of 2, the problem might be given as follows: The nucleus of the sulphur atom carries a positive charge equal to 16 (for this the evidence is good); how many alpha particles does it contain? The obvious answer is 8. If the number of alpha particles is 8, what is the weight of the sulphur atom? Answer $8\times4 = 32$, which is the atomic weight of sulphur as given by experiment.

If this system holds exactly the following theoretical table should give the atomic weights and the charges on the nucleus, the latter being equal to the atomic number:

Atomic Number	Atomic Weight
2	4
4	8
6	12
8	16
10	20
12	24
14	28
16	32

Now, the extremely remarkable fact is that *the atomic weights given above are the atomic weights of the even numbered elements*, with only one exception.

If the twenty-six elements from helium to cobalt (atomic weights from 4 for helium to 59 for cobalt), inclusive, are considered, it might be assumed that the even numbered, or one half of the elements, should have atomic weights divisible by 4. Indeed, while there are two exceptions to the exact system, just 12 of these elements do have such atomic weights, and every possible multiple of 4 but two is taken, as is shown in the following table:

1×4 = helium	8×4 = sulphur
2×4 = missing, and replaced by $2\times4+1$	9×4 = missing, but replaced by 10×4 = argon
3×4 = carbon	10×4 = calcium
4×4 = oxygen	
5×4 = neon	12×4 = titanium
6×4 = magnesium	13×4 = chromium
	14×4 = iron

Thus, since the *even-numbered* elements of *high atomic weight* give off *helium atoms* when they disintregate, and in such a way

Digitized by Google

that for each helium atom lost the *heavy atom* changes into the atom of the element which has an *atomic number which is smaller by 2;* and since the *even-numbered elements of low atomic weight* have *atomic weights which increase by four, or the atomic weight of helium, for each increase of 2 in the atomic number, the natural assumption is that the even numbered elements are compounds of helium.* To distinguish them from chemical compounds they may be called intra-atomic. At least for the elements of low atomic number, their general formula is nHe', where the prime is added to indicate an intra-atomic compound. That is, the formula of the nucleus is $n\alpha^{tt}$.

While the nucleus of the carbon atom consists of 3 alpha particles alone, and that of sulphur of 8 alpha particles, and while the other nuclei which consist of 4, 5, 6, and 7 alpha particles are also well known atoms, no nucleus contains more than ten alpha particles unless it contains some negative electrons other than those in the alpha particles themselves, which are used in binding on extra alpha particles. Thus the argon nucleus consists of ten alpha particles plus 2 negative electrons, while the nucleus of the calcium atom consists of 10 alpha particles without any negative electrons aside from those inside the alpha particles. Thus the argon and the calcium nucleus contain the same number of alpha particles, but not the same number of negative electrons. The only difference between an argon and a calcium atom is that the former has two electrons in its nucleus, which in the calcium atom are in the outer shell of the planetary electrons, that is they are valence electrons. Thus the argon and calcium atoms are *isomeric.*

The Negative Electrons in the Nucleus Are Associated in Pairs.

The negative electrons which are used in binding extra alpha particles on the nucleus always go in pairs, and may be called cementing electrons. It is these cementing electrons in the radio-active atoms which are thrown off at high speeds as beta particles. It is of interest to note that *atoms very seldom contain an odd number of negative electrons,* and that they are more apt to contain an even number than an odd number of positive electrons. This means that *nuclei with an even net positive charge are much more abundant than those with an odd numbered charge, that is the even numbered atoms are much the more abundant.*

How Are Atoms of Odd Nuclear Charge (Odd Atomic Number) Formed?

If the principal complex constituent used in atom building is

Digitized by Google

the nucleus of the helium atom, that is the alpha particle, and if this always carries two positive charges, and if negative electrons add themselves two at a time, the question may well arise, "How can an atom of odd nuclear charge be formed?" The answer lies in the fact that there exists another particle, similar to the alpha particle, but which consists of three positive and two negative electrons, that is its formula is $(h,e)^+$ and it carries one positive charge, so that any atom which has in its nucleus one of these particles, will have a nucleus with an odd numbered charge. At the present time *we know of no atomic nucleus in which more than one of these particles is present.* We may call this the *nu* particle. It is the nucleus of the atom of meta-hydrogen, which is an isotope of hydrogen, with an atomic weight equal to 3.00, but which has not as yet been found by itself.

In general any nucleus of odd numbered charge has the same composition as the even numbered nucleus with one less charge, except that the nucleus of odd number contains one *nu* particle.

HOW ISOTOPES ARE FORMED BY THE ADDITION OF MU PARTICLES, OR BY THE ADDITION OF HELIO GROUPS.

That isotopes exist was first discovered by Soddy, who found them among the radioactive elements. What are isotopes? The isotopes of lead act the same as lead in all chemical actions, and also have the same melting points, as found by Richards, and the only known difference of any considerable magnitude, is that the atomic weights are not the same, but differ in steps of two. Since the atomic weights are different and the atomic volumes the same, the densities are different.

Five years ago I developed a theory according to which all of the *actual atomic weights on the oxygen basis* are very close to whole numbers. When the atomic weight given in the atomic weight tables differs much from a whole number, this indicates either that the determination is inaccurate, or that the element is a mixture of different isotopes of the element. Thus chlorine, according to the tables, has an atomic weight equal to 35.46, while my theory gave 35.0 as the atomic weight of normal chlorine. With the aid of C. E. Broeker, W. D. Turner, and T. H. Liggett, I have had diffusion experiments carried out on chlorine for the past five years. The latest work, done together with Mr. Broeker, seems now to indicate that *we have separated the element chlorine into a heavier and a lighter fraction, which shows that it is a mixture of isotopes.* This is in accord with the work of Aston, who, by positive ray analysis, finds that normal chlorine has an atomic weight equal to 35.0, and meta-chlorine has an atomic weight of 37.0.

Digitized by Google

In general, isotopes are formed by the addition to the nucleus of the atom of the element which has the lowest atomic weight, one mu group, or the group $h_2^+\epsilon_2^-$. This group is as a whole electrically neutral, so if it is added to the nucleus of an atom, the weight increases by the weight of the 2 h particles, or by 2.0, but the charge on the nucleus remains the same. Now any atom with a positive charge of 17 on its nucleus is a chlorine atom. The formula of the normal chlorine nucleus is $(a_8n)^{17+}$ where a stands for the alpha, and n for the nu group. The formula of the nucleus of the isotope of chlorine is $(a_8nm)^{17+}$. A second type of isotope, known only among the heavy atoms, is formed by the addition of the group $(h_4^+\epsilon_4^-)$, which also has no net charge, and therefore does not change the numerical value of the nuclear charge of the atom to which it is added. This group has the same composition as the helium atom, but differs from it in that all of its negative electrons are in the nucleus, while in helium two of the electrons are outside. We may call this group the *helio* group, to show its analogy to and differences from the helium atom. The helio group is one alpha particle plus the cementing electrons used in cementing it on the nucleus of the complex atom.

THE COMPOSITION OF LIGHT ATOMS.

To illustrate the structure and composition of atoms, the composition of the light atoms is given in Table 1.

TABLE II.

The Hydrogen–Helium–Lithium System of Atomic Structure H=1.0078. He=(4 H)=4.00

	1	2	3	4	5	6	7	0	8	
At. No	3 Li	4 Be	5 B	6 C	7 N	8 O	9 F	10 Ne		
Ser. 2	$He+H_3$	$2He+H$	$2He+H_3$	3He	$3He+H_2$	4He	$4He+H_3$	5He		
Theor.	7.00	9.0	11.0	12.00	14.00	16.00	19.00	20.0		
Det.	6.94	9.1	11.0	12.00	14.01	16.00	19.00	20.0		
At. No.	11 Na	12 Mg	13 Al	14 Si	15 P	16 S	17 Cl	18 A		
Ser. 3.	$5He+H_3$	6He	$6He+H_3$	7He	$7He+H_3$	8He	$8He+H_3$	10He		
Theor.	23.0	24.00	27.0	28.0	31.00	32.00	35.00	40.0		
Det.	23.0	24.32	27.1	28.3	31.02	32.07	35.46	39.9		
At. No	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn		26 Fe	27 Co
Ser. 4.	$9He+H_3$	10He	11He	12He	$12He+H_3$	13He	$13He+H_3$		14He	$14He+H_3$
Theor.	39.00	40.00	44.0	48.0	51.0	52.0	55.00		56.00	59.00
Det.	39.10	40.07	44.1	48.1	51.0	52.0	54.93		55.84	58.97

Increment from Series 2 to Series 3 = 4He. Increment from Series 3 to Series 4 = 5He (4 He for K and Ca). Increment from Series 4 to Series 5 = 6He.

Note: The simple helium system begins with carbon (= 3 He), and continues with oxygen (4 He), neon (5 He), magnesium (6 He), silicon (7 He), sulphur (8 He), argon (10 He), calcium (10 He), titanium (12 He), chromium (13 He) and iron (14 He).

While both the argon and the calcium atom are built from 10 helium atoms, the nucleus of the argon atom contains 10 alpha (α) particles alone, while the nucleus of the calcium atom contains 10 alpha particles with two negative electrons which serve to bind on one of the alpha particles. These may be called binding electrons.

The composition of the thorium nucleus is expressed by the formula $a_{58}\epsilon_{24}$, that of the nucleus of the uranium atom by $a_{58}h_2\epsilon_{28}$, and that of the isotope of lead which comes from radium as $a_{51}h_2\epsilon_{22}$.

Digitized by Google

a = the alpha particle, mass = 4.00, and charge = 2
n = the nu particle, mass = 3.00, and charge = 1
m = the mu particle, mass = 2.00, and charge = 0
ϵ = the negative electron in the nucleus.
h = the positive electron.
ϵ' = a non nuclear or planetary electron, which is not in the outside or valence shell.
e = a non-nuclear electron in the valence shell.
$a = (h_4\epsilon_2)^{++}$ $n = (h_2\epsilon_2)^{+}$ $m = (h_2\epsilon_2)$

TABLE 1.

Composition of Light Atoms.

Atoms of Even Nuclear Charge.						Atoms of Odd Nuclear Charge.					
Nuclear Charge and No. of External Electrons.	Symbol of Element.	Composition of Atom.	Nucleus.	Electrons. Inner.	Valence.	Nuclear Charge and No. of External Electrons.	Symbol of Element.	Composition of Atom.	Nucleus.	Electrons. Inner.	Valence.
2	He	He	a	ϵ'_2		3	Li	HeNu	an	ϵ'_2	e
4	Be	He_2H	a_2	ϵ'_2	e_2	5	B	He_2Nu	a_2n	ϵ'_2	e_3
6	C	He_3	a_3	ϵ'_2	e_4	7	N	He_3H2	$a_3h_2\epsilon$	ϵ'_2	e_5
8	O	He_4	a_4	ϵ'_2	e_6	9	F	H_4Nu	a_4n	ϵ'_2	e_7
10	*Ne*	He_5 / He_5m	a_5 / a_5m	ϵ'_{10}		11	Na	He_5Nu	a_5n	ϵ'_{10}	e
12	*Mg*	He_6 / He_6m	a_6 / a_6m	ϵ'_{10}	e_2	13	Al	He_6Nu	a_6n	ϵ'_{10}	e_3
14	*Si*	He_7 / He_7m	a_7 / a_7m	ϵ'_{10}	e_4	15	P	He_7Nu	a_7n	ϵ'_{10}	e_5
16	S	He_8	a_8	ϵ'_{10}	e_6	17	*Cl*	He_8Nu / He_8Nu-m	a_8n / a_8nm	ϵ'_{10}	e_7
18	A	He_{10}	$a_{10}\epsilon_2$	ϵ'_{18}		19	K	He_9Nu	a_9n	ϵ'_{18}	e
20	Ca	He_{10}	a_{10}	ϵ'_{18}	e_2	21	Sc	$He_{11}H$	$a_{11}\epsilon_2h$	ϵ'_{18}	e_3
22	Ti	He_{12}	$a_{12}\epsilon_2$	ϵ'_{18}	e_4	23	V	$He_{12}Nu$	$a_{12}\epsilon_2n$	ϵ'_{18}	e_5
24	Cr	He_{13}	$a_{13}\epsilon_2$	ϵ'_{18}	e_6	25	Mn	$He_{13}Nu$	$a_{13}\epsilon_2n$	ϵ'_{18}	e_7
26	Fe	He_{14}	$a_{14}\epsilon_2$	ϵ'_{18}	e_8	27	Co	$He_{14}Nu$	$a_{14}\epsilon_2n$	ϵ'_{18}	e_9

The symbols in italics represent elements for which there are two kinds of nuclei (isotopic). Note that they all lie close together in the table, and that only one of the four is of odd atomic number.

Table II explains the fact which has been so great a mystery to chemists, that argon has a heavier atom than potassium, though it appears before potassium in the periodic table. This is due to the fact that the argon nucleus contains two cementing electrons which are absent from the potassium nucleus. The two cementing electrons bind on an extra alpha particle, so the argon nucleus has a mass of 40 instead of the normal value 36. This is shown even more plainly in Table 1, which indicates that all of the even numbered atoms of higher atomic number than argon, with the exception of calcium, have these two cementing electrons (ϵ_2) in their nuclei.

(To be continued.)

Digitized by Google

WHAT SHOULD THE CHEMISTRY TEACHER KNOW?

By Frank B. Wade,
Shortridge High School, Indianapolis.

The excellent article by C. L. Vestal on "What Should the Physics Teacher Know?" in the February School Science brought us the request that we do something along similar lines for the chemistry teacher. We heartily agree with the broad contention of Mr. Vestal that it is not merely the subject but the community bearings of the subject, the social and civic relationships of the science, that should most concern the teacher.

To be sure the well trained teacher must know his subject, and not merely the more elementary portions of it that he will likely teach, but also much of the more advanced part, which will enable him to see the elementary part in its true perspective, and which will permit him to teach it truthfully, even though not completely.

Having had frequently to make out examination questions to be taken by teachers of chemistry who were candidates for entrance into a large city school system, the writer has been forced to consider what parts of the great field of chemistry the well-trained high school teacher of that subject should have studied. The conclusion was reached, that, in addition to much general inorganic chemistry, the teacher should have had courses in qualitative and quantitative analysis, in organic chemistry and in physical chemistry at least, and further, that courses in physics, and in biology, were almost essential and courses in geology, astronomy, and bacteriology very desirable.

So much for the subject matter that the well-trained teacher of high school chemistry should have at his disposal. He will need it all if he is to properly teach his pupils—not merely the small, well-selected portion of it that the time at his disposal will permit, but also the historical setting, the interrelationship with other parts of the great field of science, the service that the science has rendered and is rendering to mankind, and the applications of it to the pupil's own life and surroundings. It will often take every bit of the above training to answer intelligently and successfully many of the host of questions which one's pupils will ask.

The extended question box of Mr. Vestal's article reminds us of a bit of verse from Charles F. Adams' "Leedle Yawcob Strauss":

Digitized by Google

He asks me questions sooch as dese:
Who baints mine nose so red?
Who vas it cut der ɛch noodth blace oudt
Vrom der hair ubon mine hed?
Und vhere der plaze goes vrom der lamp
Vene'er der glim I douse?
How gan I all dese dings eggsblain
To dot schmall Yawcob Strauss?

Any teacher of chemistry of some years' experience can recall many questions that have been proposed by pupils, which are no whit easier of answer than those of Yawcob. In fact many questions put by pupils betray much lack of understanding of the particular situation and much of the teacher's time will be needed in straightening out tangled conceptions of relations before attempting to enlighten the pupil specifically in regard to the matter in interest.

The wise teacher will not always attend to answering questions in class time. Indeed would it not be better not to so attend to them except in cases that naturally lead, or cases that can readily be made to lead, to the theme in hand? May I cite an actual case of recent occurrence to illustrate my point? The class was considering the bleaching action of chlorine water, and the intermediate formation of hypochlorous acid and its subsequent decomposition was the new theme that was to be presented. The chlorine in actual use had been generated by the oxidation of HCl by means of $KMnO_4$. A returned service man in the class, still a bit flighty as many of them are, wanted to know why the chlorine might not better have been made by the electrolysis of brine, saying that that was the way it was made for use in gas attack. The question, while *à propos* as regards the preparation of chlorine, was not in order as regards the functioning of HClO in bleaching, and my first impulse was to turn aside the question, but there was the real live interest of the boy, and also that of the class, in his question, which bore on recent military chemistry, so I quickly shifted my ground, took up his question, explained the primary reaction in the brine cell and then, citing the local case of the laundry which advertised "We do not use harmful bleach, we use nothing but pure water, pure salt and electricity," I explained the secondary reaction that produced sodium hypochlorite in the cell. I next likened this reaction to that between chlorine and slaked lime in the manufacture of bleaching powder, showing that the laundry which made its own bleach and the one that bought bleaching powder were working along closely similar lines, and then I got

Digitized by Google

back to my original theme by showing that the interaction of chlorine and water, like that of chlorine with sodium or calcium hydroxide, produced both a chloride and a hypochlorite but that in the case of water it was the hydrogen salts, that is, the acids, that were produced. The ease with which HClO might be formed from the metallic hypochlorites, its instability, and consequent oxidizing power, were then taken up and I was back on the track so to speak. Perhaps, had I stayed on the track I should have been in a rut (if that is not mixing metaphors) so may we not then regard as legitimate for answering in class all questions that show genuine interest and that lead toward or may be made to lead toward the topic in hand? Extraneous questions, or questions of interest only to the asker, might well be answered after class. In such cases, if the nature of the question permits, the pupil himself can well do most of the work, in obtaining the answer, whether in the laboratory or with reference works. Moreover, requiring participation on the part of the pupil will test his interest to see if it is genuine and he will get vastly more out of the investigation if he participates in it even though under guidance.

Mr. Vestal remarks of his physics questions that "most of them are not answered in the high school texts, except it be in such a remote and indirect way that no ordinary individual would see the implied answer." Nor are the big questions of life directly answered for us anywhere. Always, whether in the field of research or that of morals, we are forced to seek out and apply the principles that underlie the particular situation. Can we do better for our pupils than to help them not merely to dig out for themselves the desired answer, but to show them how to go about it?

In conclusion, my answer to the question "What Should the Chemistry Teacher Know"? would be, first, enough of subject matter, and of the means of getting it, so as not to be at a loss for necessary material; second, how to discern whether or not questions put by pupils are in order (or may be made to fall in line); third, what is going on in the community that is most related to his subject; he should also know the men who are doing these related things; fourth, and most important of all, the teacher should know how to go about showing the pupil how to solve problems for himself.

For the sake of the teacher who has not been long enough at the game to have accumulated a mass of sample questions,

Digitized by Google

there follows a list of questions that have been asked, most of them recently, in my own department. For many of these I am obligated to my associate teachers, Miss Dorothy Bowser, Mr. John R. Kuebler and Mr. Joel W. Hadley and to numerous pupils in the department who have had a desire to know the whys and wherefores of things chemical.

1. How can I tell if this is gold (presenting a specimen of iron pyrites)?
2. Why does salt, when thrown on the fire, help clean out the soot in the chimney?
3. How do "vinegar bees" turn sugar into vinegar?
4. How can I tell if this is a counterfeit dime?
5. What is the gray stuff in those long red tin cans that are used as fire extinguishers?
6. What is in a "pyrene" fire extinguisher?
7. Is there any magnesium in that bright light that the street car repair men make where they have a sign that says "Danger, do not look at the light"?
8. Can the chemist make diamonds?
9. What makes soft coal smoke?
10. Why does water put out fire?
11. Why do barns sometimes get on fire when they have improperly cured hay stowed in them?
12. Why doesn't gold tarnish?
13. Is this copper ore?
14. Why is the oxy-acetylene blowpipe flame hotter than the oxy-hydrogen flame.
15. Is this a real pearl? (Or real coral?)
16. Why do they lower burning paper into a cistern or well before going down to make repairs?
17. How do they make the gas for soda water now the breweries are out of business?
18. How did they get so much helium for use in balloons during the war?
19. How does a gas mask work?
20. Is hydrogen peroxide a good antiseptic?
21. Are "synthetic rubies" real rubies?
22. Why isn't gasoline as good as it used to be?
23. Why does the tinner use muriatic acid in soldering?
24. Is ozone good for you?
25. What makes chlorine bleach?
26. What is in the two bottles of the ink eradicator outfit?
27. What is Phosgene and why is it so mean?
28. How does the jeweler test gold?
29. How is it that they use salt both to freeze ice cream and to melt ice on the car tracks?
30. What makes sodium skip around so when you throw it onto water?
31. What is radium?
32. Why burn zinc in a fire in order to remove soot from the chimney?
33. What gas do they use in balloons?
34. Why does an aluminum plate with a soda solution clean silver ware that is kept in contact with the plate?
35. Why does Ivory Soap float?
36. What is the deposit in a teakettle?
37. What is the difference between clinkers and ashes?
38. What is "colorless" iodine? Is it any good as a counter irritant?
39. Why does a furnace smoke pipe rust so in summer?
40. How does "Climalene" soften water?
41. Why do you fill the bottle in the chemical fire extinguisher only half full of concentrated sulphuric acid?

Digitized by Google

42. Why is cistern water soft and well water hard when they both come from the clouds?
43. Why is lime water good for sour stomach?
44. Why does hydrogen peroxide foam when it comes in contact with blood?
45. How do they make hydrogen peroxide?
46. What is manganese and what is it good for?
47. Why are metals more apt to crystallize in cold weather?
48. What is it that baking powder contains that makes cakes rise?
49. Why isn't rubber acted upon by acids?
50. How is glass made transparent?
51. What causes cement to harden?
52. Why do they always use distilled water for storage batteries?
53. Why is ammonia given to a person when she is fainting?
54. What does the iron, taken as a medicine, do for the body?
55. Why is sulphur used as a medicine?
56. Why is the oxide on iron porous while that on copper and lead is not?
57. Why do some brands of ink turn black after they have been written with?
58. Does dynamite exert an equal force in all directions when it explodes?
59. Could diamonds of commercial size be made with some of the new explosives used in the war?
60. Can dynamite be exploded by hitting it with a wooden club?
61. Would an animal, a mouse for instance, die more quickly in a vacuum or in a chamber having greatly increased air pressure?
62. Why is baking powder used in cake, and soda (with sour milk) in biscuits?
63. Why does the water in ice cream sodas bubble?
64. Why is egg put in some baking powders (although it is not used as a substitute for egg)?
65. What makes the white numbers on a black watch dial visible in the dark?
66. How does water get purified in the soil?
67. Why does copper turn green in the air?
68. What is the chemistry of sour milk?
69. Why is gold used for fountain pen points?
70. What is the white metal on the very tip of a gold pen?
71. What per cent is the solution of acid and water in the storage battery?
72. If the negative and positive wires are connected it will blow the fuses but if the current is passed through a solution of water and acid the fuses will not blow. Why is this?
73. Why does a mixture of hydrogen and oxygen explode?
74. What is the substance that forms on the inside of a teakettle?
75. What is the composition of "Carbonoid" and how does it work?
76. What is the difference between steam and water vapor? If they are the same, why doesn't water vapor condense at a temperature below 100?
77. How are the fusible metals, such as are used in automatic fire sprinklers, made?
78. What is in "Carbona" that prevents it from being as dangerous as gasoline when used as a cleaner?
79. How are "sparklers" made?
80. What makes aluminum dishes blacken when some vegetables are cooked in them?
81. Why does salt make a flame clearer?
82. Why is mercury, rather than something else, used in most thermometers?
83. Why does soap lather when water comes in contact with it?
84. How can pewter be cleaned?
85. Why do they put sugar in soap?

Digitized by Google

86. Why do people put tin cans in the furnace?
87. Why do butchers and refrigerating plants use ammonia?
88. How does salt help to make things freeze?
89. Is pewter a mixture of substances?
90. If hydrogen gas is lighter than oxygen gas why can't it be separated in a bottle the same as a liquid that is heavier than another?
91. Why does sulphuric acid eat up zinc and not lead?
92. Why do not the wires in an electric light melt?
93. What becomes of the weight after a piece of wood burns? The ashes weigh much less than the wood.
94. Why does mercuric oxide return to mercury with oxygen all around it?
95. Why does water bubble when it boils?
96. What is "smelling salts"?
97. When butter stands for any length of time, what makes salt collect on its surface?
98. What causes soda, when put in sour milk, to bubble up?
99. What makes cream when churned turn to butter?
100. Why does bluing turn clothes white?
101. When canned goods spoil what causes the can to bulge?
102. When milk sours and water comes to the top what is the cloudy substance that is formed at the bottom and why does this substance separate from the water?
103. What is in chocolate that makes people fleshy?
104. Why is it that to take iron as a medicine will turn your teeth dark?
105. What is in a lemon that will take stains out of clothing when other methods fail but still without eating it?
106. What is it in shoe polish that makes your shoes shine?
107. What makes soft water soft and hard water hard?
108. Why does gasoline evaporate more readily than water?
109. When bread moulds is it the same kind of action as when iron rusts?
110. What is the difference between hard and soft soap?
111. What does our city gas contain that makes it poisonous?
112. Why do some articles fade when exposed to the air and sun?
113. Why does hot water dissolve soluble substances quicker than cold water?
114. Why does sassafras tea thin the blood?
115. Why is plate glass green?
116. Why does oil rot rubber?
117. What is there in the exhaust of a gasoline motor that is poisonous?
118. Why does putty get hard when standing a long time?
119. Why does rubber become weak after a long time?
120. Why does old paper turn yellow?
121. How does putting an agate in lard take the moons out?
122. Why does salt make whitewash stick?
123. What is the difference in the constituents of colors that fade and those that do not?
124. Why is a gas flame blue?
125. Why does heat restore life to a battery?
126. Why does salt become lumpy after standing for awhile?
127. Is there any way water could be mixed with oil?
128. What is there in an indelible pencil that will not erase whereas a lead pencil mark will?
129. What is there in peroxide that bleaches hair?
130. Why does the blood look blue in your veins?
131. What is the green substance that forms on the end of a water faucet?
132. Why is it that some matches will strike anywhere while others have to be struck on the box?

Digitized by Google

133. Why is it that onions cause gas to form in the digestive organs?
134. What is it in ether and chloroform that makes people go to sleep?
135. What is it in gasoline that makes it clean garments?
136. What impurities are in water that makes it impossible for use in storage batteries?
137. What is milk composed of?
138. What makes cement become hard when mixed with water?
139. What is there in gasoline and alcohol, and in anti-freeze mixtures that keeps the radiator from freezing?
140. What is there in carbontetrachloride that makes it put out fires?
141. How do automatic gas lighters work?
142. How do the gas lighters that have a round file, and a piece of metal to be rubbed on the file, give such hot little sparks so easily?
143. What is the best way to change hard water to soft? Is there some safe chemical that can be used at home?
144. How can one tell whether such things as "Dutch Cleanser," "Bon Ami" and washing powders are injurious?
145. Why does hot fudge sizzle when vanilla is put in it?
146. When a gas explosion occurs in a house why do the windows sometimes fall in instead of out?
147. Why is soot rather than diamonds (both of which are carbon) formed from the incomplete combustion of coal or oil?
148. Why does guncotton not explode when a lighted match is applied?
149. Why does the carbon in an old fashioned electric light not burn?
150. Why do "Lux" flakes not shrink woolen fabrics?

FUNDAMENTALS IN METHOD—OLD AND NEW.[1]

By Charles J. Pieper,

University High School, Chicago.

Obviously the scope of the subject assigned to me for discussion today is too great to allow a detailed consideration of the many important phases of methods in teaching secondary chemistry. It is necessary therefore that only a few outstanding developments in our method be considered. While discussing these I shall attempt to include the various points mentioned in the committee's questionnaire. From a consideration of these developments we shall find certain valuable suggestions which, adapted to our present teaching, will insure for our students a more permanent interest in chemistry, a more thoroughly scientific study of the subject, and a more economical and profitable use of their time spent in the laboratory and class study.

With the permission of the chairman I shall reverse the order of that part of the topic for discussion which reads "New and Old" and consider (a) The Early Lecture Method, (b) The Laboratory Method and Its Abuse, and (c) The Present Method, with suggested changes.

The Early Lecture Method.

If we accept the statement in many recent articles on the worn

[1]Read before the Chemistry Section of the C. A. S. & M. T. Lake View High School, Chicago, Nov. 29, 1919.

Digitized by Google

topic "Decline in Science Enrollment" we agree that the popularity of our subject has waned. Undoubtedly one of the factors in the decline is the loss of interest which the study of chemistry has suffered. This is chargeable to the present formal manner with which we present the abstract subject matter.

In the earlier days chemistry was not taught better, considering the many values which accrue from a thorough study of the present courses, but it was taught in such a way that the student's interest was fostered and maintained. This living interest resulted because the student was not burdened with a tremendous number of unrelated facts and details, because the subject was less extensive, and because what was done was done so thoroughly that the student saw clearly the interrelationships of the parts, and the relation of his study to his everyday experiences and to the place of chemistry in the general progress of the day.

Perhaps there are a few in this group who were fortunate enough to gain their first view of chemistry through the lecture method. I say fortunate, even though I am conscious of the many shortcomings of the course. The enthusiastic teacher, "brimming over" with chemistry, clarified his careful discussion with simple demonstrations and with practical applications. As carefully was the student led to see the major relationships, using only such facts and observations as were necessary to cause the concept to be "clear as a crystal." The lectures were informal and always related to the everyday experiences of the students. There was no hurrying through the course in order that sixty-two experiments and 348 pages of the textbook might be completed in the 36 weeks of the school year. The student was not lost in a mass of unrelated observations, terms, facts, symbols, formulas, theories, equations, and laws such as we attempt to wade through in so many of our first year courses today. The course was intensive and in the end the student was able to see it as a continued story with each chapter in its proper order and setting.

Of course, the lecture method had its disadvantages. It was a second-handed method of study. Slower students did not thrive on the predigested knowledge administered in predetermined doses. They were not gaining "first-hand" those invaluable results which are acquired through individual experimentation. It was not the natural method of self education. Moreover, chemistry was rapidly growing and demanded a more extensive course.

Digitized by Google

But, to repeat, through such course, no matter how many and how great the shortcomings, was developed a projected permanent interest, a spirit of thorough scientific study, and a feeling of satisfaction in something thoroughly done. Such results built the foundation for continued progress and enthusiasm in the subject.

The Laboratory Method and Its Abuse.

Out of the shortcomings of the lecture and the later textbook method arose the demand for laboratory study. Since the first laboratory was established at Harvard, in 1846, every college and practically every high school has followed Harvard's example. The subject had developed so rapidly that selection from a tremendous field of concepts and topics was necessary. The colleges made the selection, outlined the laboratory experiments and handed down the organization to the secondary schools. Important principles and theories were so numerous that they usurped the major part of the course and the high school pupil found himself in the laboratory, much of the time, attempting to verify the deductions of the mature scientists.

The laboratory work grew and grew. The stockrooms were piled high with apparatus necessary to establish this or that principle. In fact, every principle or concept, it seemed, must be learned in the laboratory, no matter how difficult or how dangerous the experimentation necessary. No account of economy of time was taken. Worse still, no serious attempt to relate the laboratory work to the larger topic or problem was made. The laboratory work was, and still is, in some places, formal, even to the distribution of chemicals. Added to these faults the laboratory and class work were separated, as if they were two distinct phases of chemistry instruction. Two years ago I visited a school where the chemistry teacher told me that he no longer used any textbook or reference book since he believed that the laboratory method was the only method to be used in studying chemistry. Luckily for his students he was a thorough student of chemistry and was able to give them in discussion much that is found in the average textbook. Allow the inexperienced teacher to teach chemistry in this way and you insure even poorer results than are obtained by the textbook method with no laboratory work.

From one extreme to the other the pendulum has swung. The picture is not too dark, I am convinced when I visit various classes in our high schools. Too frequently little consideration

Digitized by Google

is given as to the best method of presenting the particular topic for study. Perhaps the demonstration method would save much time and in the end the student would have a clearer concept than when he attempts aimlessly to discover for himself the all important truths. Perhaps the problem could be more effectively solved by the use of the textbooks or the reference library. The particular case must determine the method.

The Present Method, with Proposed Changes.

Now the pendulum is swinging to the halfway mark. There are fortunately, many teachers thoroughly enough versed in methods of instruction who see that a combination of the good qualities of the various methods affords the most effective and profitable training in science. These teachers are not carried to extremes; they are conscious of the needs of boys and girls and plan their units of instruction accordingly. Units of subject matter are a secondary consideration. Their first consideration is: How can I most effectively, economically, and thoroughly teach my pupils to scientifically solve the problems which arise in their out-of-school experiences or which develop in the previous study, and to see clearly the relationships of the various problems so that they will gain a chemical and scientific point of view?

The method which they use is in many respects the true research method and as such is a combination of the good qualities of the lecture method, the demonstration, the individual experimentation, field excursion, reading, consultation with authorities, and class discussion. It is, in a word, live chemistry.

This does not mean that every problem will proceed through all of the above steps. It does mean that the problem will be classified by the teacher as of this or that type for which type a certain combination of methods will be employed. It means that we will begin to study the problems and concepts in such a way, through experimental teaching, that we will be better able to know which methods yield the greatest returns for the time spent. On this question we need experimental evidence, just the kind of scientific evidence which we insist our pupils shall have before they arrive at a conclusion to a problem. The means of approach cannot be decided upon by a general questionnaire. The fundamental concepts and topics must first be established and then must follow experimental teaching and careful testing of results.

Digitized by Google

The course in chemistry will be a course of solving chemical problems, of establishing chemical concepts. It will be a thoroughly scientific course. The problems will be presented or motivated through a discussion of past experiences, assigned reading, informal lecture or demonstration. The means of approach which arouses the greatest desire to solve the problem will be chosen. It will often be the most common practical application of the principle or the strange phenomenon observed by the pupil. The pupil will be brought face to face with a problem. A challenge to his ability will result. In a true research way he will attempt to gain such evidence or information as is required to solve the problem. The larger problem, or project if you wish, will be inclusive of many smaller problems and topics. I recall an illustration from my own classes which will help to elucidate the point. During a short discussion on fire, as a type of chemical change, one of my pupils asked, "Why do you blow a match to extinguish it, but blow a fire to make it burn?" I jumped at the opportunity offered, and before we had successfully answered the question, we had studied oxygen, requirements of combustion, the percentage of oxygen in the air and several related topics and applications. Always the problem was with them, and through its motivation they were able to relate all of the smaller problems and topics. And here I should agree with the questionnaire which suggests that the larger units or problems should be inclusive of many smaller topics. It is through such organization and method that pupils see the larger relationships involved.

Once the problem is clearly before the pupil he will eagerly seek the evidence necessary to answer it. The evidence will be gained by demonstration, experimentation, reading, consulting authorities, and in any other way possible. Here, again, there is no set rule. The concept or topic or problem will govern the procedure. It is wholly doubtful if we can justify sending the pupil to the laboratory every time evidence is needed. I am sure that we cannot justify the individual experimentation which is so commonly carried on without a clear purpose in the pupil's mind. I feel equally certain that the pupil should often know without laboratory directions what he must do and how he must do it. Pupils waste an enormous amount of time aimlessly experimenting because there are so many experiments to be done in a year and because the detailed directions ask him to do this and that.

Digitized by Google

My contention is not against the present laboratory work in general. It is against laboratory work done without a definite purpose, done unintelligently, and done when assigned reading or a demonstration would yield the evidence required in less time and far more certainly.

Following the gaining of the evidence, yes, during the process, must come frequent short discussions. How often our pupils come to us during the laboratory period, or immediately following, with the question, "When are we going to talk about this to find out what it is all about?" Just the other day two pupils asked me that very question at the close of a laboratory period on the reactivity of metals, when I had supposed that they were clear in the purpose of their experimentation. And now we are ready for additional evidence and information. Where shall we go for it? Any place and every place where we can find it. First, to the definite assignments in the text books and library books; second, to the industry or other actual application; third, to charts, illustrations, exhibits, fourth, to pamphlets of information from industries, to state and city department reports, and to government bulletins; fifth, to home projects; and so on to any other source. And happy may the teacher be if during his years of service he has collected and has had his pupils collect such supplementary materials. His laboratory is a real workshop, a place for research on problems that are just as real to the pupils as is a research problem to the specialist.

But, I hear, what about the time necessary? There is but one answer to this. Have your materials so well classified and so well indexed that they are readily available. In saving time by a judicious choice of method you will do the work so thoroughly that the results will justify the procedure. It is surprising how many facts and concepts will be gained if this problem solving attitude is ever present. After all it is through thoroughness in study that the scientific method is correctly inculcated, and that is the greatest result which the student can acquire.

What will be the pupils' part in such a program? He will keep a comprehensive notebook, not a laboratory notebook only, but one which contains much more than his observations in the laboratory. Such a notebook as has been commonly prepared by my pupils is of little value. The experiments are not related; there are no connecting links. The notebook neither represents the course in chemistry nor is it of use in review. Rather than a laboratory notebook he will keep a chemistry

Digitized by Google

course notebook. This will contain a summary of the discussion in class, a statement of every problem studied, complete notes on every experiment, whether class demonstration or individual, outlines in statement form, or compositions, on all important required reading assignments and analytical or diagrammatic drawings whenever these will serve to make clearer the descriptions. There will be detailed reports on major topics.

In addition, the notebook will include a list of all new scientific terms met in the course, with a short concise statement of the meaning of the term, a table which gives the chemical name, formula, and common name of every chemical studied, a list of all equations used, and a statement of all important laws and theories considered.

All of this work will be carefully done in ink, in acceptable English form and formulated in the words of the pupil as far as possible. The pupil will have, at the end of the course, a notebook, which for him is a better source for study and review than any textbook. On the part of the teacher this will mean a definitely planned course, outlined for the pupil's guidance.

If I have indulged in glittering generalizations, it must be granted that they have been made upon the basis of experience. There is little experimental evidence in the modern sense of the term. Experimental teaching with carefully devised testing of the results must come. This I consider the greatest possible contribution of such a group as this. If we will but select a certain set of fundamental concepts and topics or problems and then try experimentally the various combinations of methods, we shall be able to verify the effectiveness of the best method.

Professor Edwin Oakes Jordan, Chairman of the Department of Hygiene and Bacteriology at the University of Chicago, has been elected a member of the International Health Board of the Rockefeller Foundation. The work of this board has been largely devoted to the study of hookworm diseases and the best means of preventing this infection. Much work has also been done and is still in progress on malaria, particularly in the southern part of the United States. The tuberculosis emergency in France during the Great War and public-health education in South America and other parts of the world have also received especial attention from the board.

Digitized by Google

CALCULATION BY GEOMETRY OF ASTRONOMICAL DISTANCES.

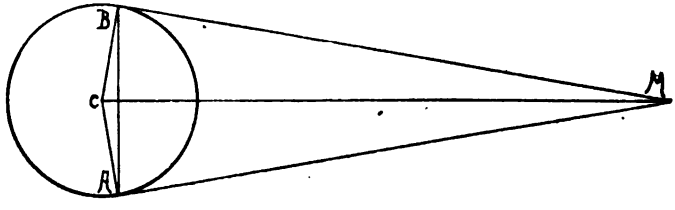
By Joseph V. Collins,
Normal School, Stevens Point, Wis.

One of the most marvelous feats of the human intellect has been the calculation of the distances between the various heavenly bodies. The difficulties in the way were terrific both as regards plans for the calculation and the making of the necessary instruments and measurements with them.

A variety of courses have been followed to attain the end sought, but to give a satisfactory glimpse of how the problem was solved, four steps in the solution will be explained.

1. Measuring the size of the earth: By measuring arcs on the land surface of the earth, noting the angles they subtend at the center of the earth, it is easy to find the circumference. Then from the circumference, the radius is found.

2. To find the distance from the earth to Mars when they are closest together, Mars being then directly opposite from the sun:[1] Let A and B be two points on the earth having the same longitude and far apart in latitude, and M the position of Mars described. Astronomers at A and B measure very accurately angles MAC and MBC, C being the center of the earth. Since B and C are known points angle ACB is known, being the sum of the N latitude of B and S latitude of A, and the angle ABC is known, since when two sides and the included angle of a triangle are known the triangle is known. By plotting triangle ABC and then angles MBC and MAC the line MC can be found, which is the distance sought. Trigonometry enables us to calculate unknown parts of triangles ABC, MAB, and MAC much more accurately than can be done by plotting to scale.



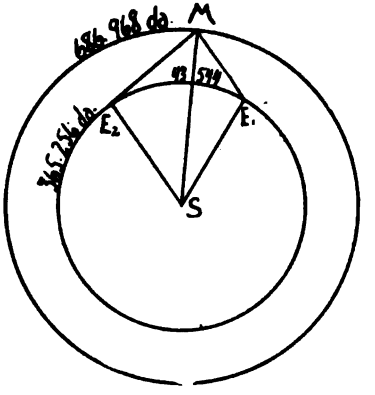
3. Measuring the distance from the earth to the sun: Clocks are made which keep time for long periods with amazing accuracy, and which can be rated or kept in good time by astronom-

[1] This method is of only theoretical applicability to Mars, though it has been applied to the moon.—Ed.

Digitized by Google

ical observations. Also by observations the time which it takes the earth and Mars to make revolutions around the sun can be found with great accuracy. The earth makes a revolution in 365.256 days and Mars one in 686.968 days.

In the figure below, let S represent the position of the sun, the inner circumference the orbit of the earth, and the outer that of Mars, and suppose M is a position of Mars at two dates 686.95 days apart, and E_1 and E_2 the respective positions of the earth at the two dates named, E_1 the first and E_2 the second. Notice the earth has made less than two complete revolutions by 43.544 days.



When the earth is at E_1 the angle SE_1M is measured in the plane of the ecliptic, that is, the difference of longitude of the sun and Mars is measured. Similarly when the earth is at E_2 and Mars is a second time at M, the angle SE_2M is measured.

Taking SE_1 any convenient length as the unit of measure, suppose SE_1ME_2 has been constructed from the measurements obtained, angle E_1SE_2 corresponding to 43.58 days. Measuring SM with SE_1, as measuring unit, let $SM = m \times SE_1$. Then, if d is the distance in miles from the earth to Mars when Mars is nearest the earth, as shown in the figure,

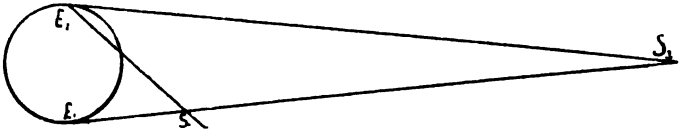
S————————E————————M

$m \times SE_1 - SE_1 = (m-1) \times SE_1 = d$, whence $SE_1 = d/(m-1)$, or distance from the earth to the sun.

4. To find distances to fixed stars; Parallax: Astronomers have found that some of the fainter stars are immensely farther away than some of the brighter fixed stars. They make use of this fact to find the distance to the nearer stars.

Digitized by Google

Let E_1 and E_2 represent two opposite positions of the earth in its orbit, S_1 a near star and S_2 one vastly farther away than the first. Suppose E_1, S_1, and S_2 are in a straight line when the earth is at E_1. S_1 and S_2 being so-called fixed stars, it is clear they will not be in line with the earth when it is at E_2. The figure shows that angle $E_1S_1E_2$ (which is called the *parallax* of the star S_1, with reference to the earth's orbit) equals the sum of angles E_2 and S_2. Now because S_2 is such a vast distance from E_1 and E_2,



its angle is so small that it can be called 0°. Thus, $S_1E_2S_2 = E_2S_1E_1$. Now if E_1S_1 and E_2S_1 are chosen so that they are equal, angles $S_1E_1E_2$ and $S_1E_2E_1$ are each equal to $(180° - E_1S_1E_2)/2$. But E_1E_2 is the known diameter of the earth's orbit, so that here again we have two angles and the included side of a triangle given to find the other sides. This calculation can be made by drawing the figure to scale, or as accurately as desired by trigonometry.

Note. Various other geometrical methods of calculating the distances apart of the heavenly bodies give results which agree well with those obtained by the methods here outlined. The distance of the earth from the sun can be found also from the known velocity of light, and the result so obtained agrees with the others. It is idle to believe that such agreements could exist and the measurements be in error, except by a negligible per cent.

Note. Professor George C. Constock of the Department of Astronomy, University of Wisconsin, who read the manuscript of this article, pointed out, as the writer had supposed, that astronomers would prefer to depend on Kepler's law for the value of m rather than on the geometrical measurements obtained in 3 above. However, it can be said that the method described in 3 is actually used, and serves the present purpose better than to use Kepler's law, that "the squares of the periods of the planets are proportional to the cubes of their mean distances from the sun."

Digitized by Google

A TEXTBOOK FOR GENERAL SCIENCE.

By Neil E. Gordon,
Maryland State College, College Park, Md.

In discussing a textbook for general science in high schools, I shall touch upon the following three points:

(1) Justification for a textbook;
(2) Content;
(3) Method of presentation.

Justification for a Textbook.

It seems to me that the opinion is altogether too common that each teacher of general science should make his own course and adapt it to the needs of his pupils. Theoretically this is fine, but it is not practical from the administrator's, teacher's, or pupil's standpoint.

I am quite in sympathy with the administrators of schools, who are becoming impatient with the indefiniteness of general science. How are they to give the proper perspective to a subject in the curriculum if that which is in the course is going to be determined entirely by the teacher?

It may be feasible for teachers in model schools or universities with allotted time for creative work to devise wonderfully adapted courses in general science, but how about the teacher who is teaching six periods a day for five days in the week? I am sure that during his vacant period he has something else to do besides devising work for the following day in general science.

Then there is the novice and faddist. They mean well, but their efforts, as a rule, are tending to make general science very indefinite and leading the administrators to demand with a great deal of justice, "What do you mean by general science?"

The students who are at the mercy of faddists, novices, and inadequately prepared teachers are surely not getting as good training, if they are being taught without a book, as they would from a correctly prepared book.

As a rule, if a teacher has specialized in one subject, she will feel that this science is better for the student than any other, and hence her course will become very one-sided. All sciences have their halls of charm, beauty, and usefulness, for the student, and the reason that we cannot see it, is that we have not taken the time or had the inclination to push open the doors that lead into these wonderful halls in other sciences.

High schools cannot hope to get the credit that they should for

Digitized by Google

general science until the period of fluctuation has passed and the high school has defined, at least in part, just what they mean by general science.

Content of the Course.

It seems to me that C. M. Howe, of Hughes High School of Cincinnati, Ohio, has tackled this "content problem" in the right spirit. He sent out a questionnaire including a list of topics for general science. The teachers were asked to mark these topics as Fundamental (F) or Supplementary (S), according to their belief that they were esssential to the subject or only possible value as optional material. You may find these results scored up in the reference cited.[1] The concordant fashion in which the teachers responded was rather significant. Could not each State profit by this advancement made by Ohio? And by means of State Teachers' Associations, each State could soon fix upon a standard minimum requirement. I say minimum requirement, for I feel that there should be a certain latitude of freedom for the teacher to put in local coloring. Such action would standardize the course while making it sufficiently adaptable to the needs of the community, and allow the teacher to develop any pet subjects to a safe extent.

Now, when the content of the course has been decided, the textbook should be written to envelop this minimum requirement so that it will make it as easy as possible for the teacher, while giving the student the maximum development.

Method of Presentation.

The method of presenting this minimum content will never have its maximum value to the student if books are written up the way that most of the general science books are today. The very way that they are written demands that they be taught by a textbook-memory method, where all projective or laboratory work of the student is given the subordinate position of merely illustrating the text, and any questions which arise are answered by reference to the text or from memory. There isn't any question that such a method is highly artificial, affords little training and tends to spoil the keen observation and exact reasoning of the student. On the other hand, I do not believe that the other extreme or project method, as commonly understood, is practical, i. e., where the student is given the project and required to work it out alone except from hints given by the

[1] School Science and Mathematics, Vol. XIX, p. 248-255.

Digitized by Google

teacher. The average teacher either gives the student too much or too little help. Either is fatal to ideal teaching.

One solution of this problem is this. Write up a book on these minimum requirements so that it will be possible for the teacher to present the subject from a projective method standpoint without working herself to death, and at the same time saving the scientific mind of the student. The book should contain such information, in the form of hints and questions as far as possible, so that the student will receive just the right kind of help and just enough so that the average student may carry out his project intelligently and without loss of valuable time. This information should have the following aim: to give the student a clear insight into the purpose of the project; and to throw light on any complications that are beyond the range of the average student. It should also contain any information that is necessary for a continuous understanding of the project, and lastly it should contain reference to some literature upon the project under consideration.

The major project may be broken up into minor projects, and each minor project may be done only by one student or a group of students. A major project as "Matter and Force" might include the minor projects gravity, weight, density, inertia, capillarity, etc. These should be put in the form of questions, as:

1. Is air matter?
2. Why does a candle burn?
3. Why do bodies fall to the earth?
4. Why does water rise in a towel?
5. How does a separator separate cream from milk?

Space should be left in the book to tabulate all observations and answer all questions so that the project will be a continuous story. To illustrate briefly:

Project: How does a separator separate cream from milk?

Apparatus: Pail (about ten quart), heavy cord, water, sawdust, separator.

Is the density of cream greater or less than that of milk?

What daily experience gives you the reason for your answer?

In the preliminary study of the project, water and sawdust will be used in the place of cream and milk.

Which will you have represent the cream and which the milk?

Give reason for your choice.

Place about two quarts of water in a ten quart pail and suspend it by means of a heavy cord so that it will be free to swing. Place some sawdust on the surface of the water. Turn the pail until the cord has acquired considerable twist. Now, let go of the pail and allow the cord to untwist.

What position does the water take in the pail?

What position does the sawdust take?

What would be the relative positions of the cream and milk were they subjected to the same experiment as the water and sawdust?

Digitized by Google

This preliminary laboratory work has put the student in a position to attack his project with intelligence. They are now ready to suggest how cream is separated from the milk in a cream separator. If this experiment is carried on in the city where the children cannot see a separator in actual use on a farm, it would be possible to have them examine one at some farm implement dealer's. It would be much better to loan one and have it at the school. Then all pupils who are interested might glean some knowledge of such an apparatus. Some of the pupils should be asked to demonstrate and describe the cream separator to the class. The Babcock butter tester will almost always come up with the cream separator. One student might be asked to make a test with this apparatus before the class.

At this time it would be quite fitting for the teacher to do some demonstrations on centrifugal apparatus, and to enlarge upon the meaning of centrifugal force.

The project may end here, for you have accomplished all and more than you started out to find, but in the purposed book you will find after this project, references in literature about the centrifuges in which crystals of sugar and salt are dried in the process of refining, and also references to explain the fact that planets revolve about the sun in nearly circular orbits because of the combined influence of gravity and inertia. The project should be enlarged upon by the students reading as many of these references as time will permit.

When the material gathered from the laboratory, textbook, demonstration exercises of the students and teacher, from the pupils' observations of commercial apparatus, and from reading references, has all been finished and digested, the student should be asked to write up a report on the project in order to clarify his ideas. The day that these reports are handed in, should be given over to the discussion of the project as a whole. The recitation should be the means of unifying, expanding, and illustrating what the pupil has learned in an experimental, vital way.

I feel confident that, if general science teachers would decide upon this minimum requirement, and a textbook were written up on these requirements by a good high school man or committee of such men, along the lines suggested above, it would make it possible for teachers with their crowded schedules to carry out this project method, which, undoubtedly, is the best method before the teaching world today.

Digitized by Google

THE GENERAL SCIENCE OF THE FUTURE.[1]

By G. M. RUCH,
University of Oregon, Eugene, Oregon.

The future of general science can only be written in terms of present and immediately past tendencies. If these prove unreliable there is no other guiding principle. General science in the past has evidenced three stages of growth. The first courses and texts were of the encyclopedic or hodge-podge variety; seemingly little more than an assemblage of condensed texts of a half dozen special sciences, and of doubtful value from the standpoint of arrangement of materials, but, at the same time, excellent handbooks for beginning students. This sort of teaching was super-saturated and committed to the false doctrine that the differences between ninth grade pupils and college students were purely quantitative in that a process of condensation and elimination of a few difficult topics would produce suitable high school courses from existing college texts.

The second chapter in the evolution of the general science course was the formulation of what might be called "unity" courses. This was a reaction to the charge of soft pedagogy and is characterized by the efforts to secure unity by building in the diverse materials about some one special science as a matrix. Some schools and most textbooks of general science at the present time show such biases toward physiology, physics, agriculture, etc., as the case may be. Perhaps this type of course was most prevalent up to the year 1918, and is by no means completely eliminated at the present time.

The last stage in this development is not so easily given a suggestive name. Perhaps, the term "Environmental Problem Courses" is most satisfactory. This type of course has definitely thrown all logical organization to the winds and is attempting to substitute a series of problems or projects bearing directly upon the school, home, and community life, from the standpoint of practical applications rather than "fundamental principles." This is the most comprehensive attempt in the history of science teaching to make the principles of science subservient to and somewhat incidental to the applications of these generalizations. Moreover, this practice has forced a complete reversal of the order of presentation of materials and by very nature of the situation *has made inductive teaching an enforced reality.* If general science has done nothing more it has made a very considerable contribution to the advancement of inductive methods in

[1]An abstract of a paper read before the Science and Mathematics Section of the Oregon State Teachers Association, Dec. 31, 1919.

Digitized by Google

the classroom. This point leads at once to the central theme of this paper—viz., *the future of general science is very largely a question of its ability to devise a suitable method.* The question of content, although not to be neglected, is of minor importance since general science cannot hope to present much content that is new, quite on the contrary much that is valuable must be omitted, but what might be done is that such content could be organized and presented in a more suitable form from the standpoint of pedagogical requirements. It is not at the door of the factual aspect of science materials that the blame for present unsatisfactory conditions must be laid, for to do so would practically be a denial of the educational values of science teaching, but, the practice of introducing eighth and ninth grade children to a technical, formal, analytical, brass-plated, electrically controlled, agate-bearinged sort of science must be deplored. It has too often come to be a case of the child losing sight of the forest for the trees. These things are the conveniences of science, not the realities. They are the man-made aspects of science. They serve to confuse, not to educate, and they often forget completely the main thing in the whole scheme of education—the mind of the child. Technique, valuable as a means, must not be substituted in educational beginnings for psychological organizations more in harmony with actual mental processes in the pupil.

This brief critical discussion opens the way to the more constructive suggestions of the future.

THE CHARACTERISTICS OF THE GENERAL SCIENCE OF TOMORROW.

If the tendencies of the present and immediate past are to be relied upon to continue, the general science of the future will be pretty sure to involve a method whose broad outlines will be characterized by widespread use of certain principles, which can here be grouped as five in number.

1. Wider use of the inductive method with the added possibility that the laboratory approach to all topics will be religiously adhered to.
2. The selection of immediate environmental problems will be the chief criterion in the determination of the content of such courses.
3. The general science course will probably be pushed back into the junior high school grades and may in cases be expanded to cover two or even three years about grades 7-9 inclusive; thus articulating with the nature study of the grades and the purer science of the higher years.
4. The general science of tomorrow will probably be problem or project science to a large extent.
5. The results obtained in general science teaching will be subjected to measurements by the use of standardized tests similar to those used in elementary school practice.

Digitized by Google

Discussion.

All of the foregoing principles are already present in some degree in the teaching of general science, although usually not all in any one school, some specializing in one, others in another. The task is to assemble these tools into a consistent method and a few suggestions as to how this is to be done will be taken up in order.

I. Inductive, Laboratory Method.

This has long been the ideal in all science. Practically everyone is agreed upon the superiority of such over pure text book or pure lecture methods, although, rather curiously, such a superiority has never actually been proved. Apart from F. C. Ayer's[2] study of the psychology of drawing with special reference to laboratory drawing and Edward J. Maynard's[3] comparative study of the relative efficiency of the book, lecture, and combination lecture—demonstration method, little experimental evidence exists. So even the laboratory method rests chiefly upon consensus of opinion. However, the fact that no absolute experimental justification of this method has ever been made is probably not to be seriously considered as casting doubt upon the superiority of inductive laboratory practice, rather, showing a curious anomaly in that science has never thought to apply its own ideas of procedure to its own internal problems.

Granting the superiority of the inductive laboratory method, there remains a practical situation to be considered, namely, that in spite of the fact that it has generally been assumed that this method is in widespread use, it is very doubtful whether true inductive laboratory teaching has ever prevailed to any considerable extent. Doubtless most of you will take issue with this bold assertion, but the actual conditions obtaining in the vast majority of schools are such as to place the most serious limitations upon any very extended use of this ideal of method. Leaving aside the very open question as to whether inductive thinking is psychologically possible over any sustained period as a question for pure psychology to answer when it may be able, there are certain purely mechanical difficulties in the administration of most of our schools which effectually block our efforts at inductive teaching. In the high schools of this state, with very few exceptions, the laboratory periods are fixed at certain

[2] Ayer, F. C.: The Psychology of Drawing with Special Reference to Laboratory Practice, 19. Warwick and York.

[3] Maynard, Edward J.: Teaching Elementary Science in Elementary Schools, Pub. 13, Div. of Reference and Research, N. Y. City Schools.

Digitized by Google

days of the week for reasons connected with the scheduling of the school program. This practically severs any close connection between the work of the classroom and that of the laboratory. Of course the text work can, in general, precede or follow the experimental exercises of the laboratory at the option of the teacher, but it is decidedly doubtful whether any teacher can ever give a truly organic connection between the two elements of instruction in opposition to this administrational handicap. Nor is this point a petty criticism, for the very nature of the inductive-laboratory method demands that *all* laboratory work on a given topic *must precede* the textbook work. As conditions exist, the best we can do is to develop our recitation work as nearly inductively as possible, while at the same time we are throwing away the best aid to inductive teaching—the laboratory—and falling back upon the much inferior plan of using the laboratory for proving the truth of the principles presented in the class recitation proper. This type of teaching is in reality nothing more than the time-honored plan of the laboratory as a place to test the truths handed out in the classroom—a method which is the exact reverse of that demanded by induction.

The difficulty here is so purely mechanical in the great majority of cases that no adequate excuse can be given for the continuation of a program which sacrifices a good method for administrative reasons. The teacher must be free to decide which days are to be utilized in the laboratory and which in the recitation room. At times, it is desirable that for weeks no textbook should be opened at all and that the entire period be spent in the development of a topic by experimentation in the laboratory. Probably, almost without exception, *laboratory work must precede textbook work in general science.* This means that the plan of double periods for laboratory work must give way to equal periods of somewhat longer length—a demand that is quite in harmony with modern administrative tendencies in that this very thing is coming as a result of the induction of supervised study which, in itself, calls for longer class periods. The advantage of this has been emphasized here and should be utilized by teachers of science as a way out of one serious difficulty.

But there is a second obstacle to be overcome that is more serious. The first was purely mechanical; the second, largely pedagogical... To teach inductively, the textbooks must be inductive in spirit and construction. As far as I am aware very

Digitized by Google

few textbooks in secondary school science can be fairly called inductive. Some teachers are succeeding in spite of the texts. We hope a good many are. What the facts are cannot be determined. It is a hopeful sign that textbooks are appearing which do develop the subject matter by a procedure working from a mass of applications of a familiar sort to the fundamental principles underlying. This method is rigidly demanded by true induction—not the reverse as characterizes the procedure of most of our texts. Recent books like VanBuskirk and Smith, Hodgdon and Trafton, to confine the discussion to general science alone, are making considerable strides in the right direction. From a nucleus like these, the future is very hopeful, even if these beginnings are still crude and unpolished. These books and a few others of their type lead one to think that there is probably more thought being devoted today to the writing of suitable textbooks from a psychological standpoint, in the field of general science, than in that of any other single science subject. Analysis of a half dozen recent texts has really made me optimistic for the future.

In the University high school, at Eugene, we have made some beginnings in the way of inductive teaching. We have adopted the plan of five equal periods per week with laboratory days falling at the will of the teacher. The subject matter has been organized as a series of fifteen problem topics, each of which involves from three to ten laboratory experiments. All of the last precede any textbook work—and no exceptions are allowed. In this way the first difficulty mentioned above has been completely obviated. The second handicap to inductive teaching has also been overome in part since the course of study does not follow any particular text and hence there is greater freedom of method allowed. The fifteen units follow each other for the most part in related order, although each is an organic unit. The separate experiments are designed so that each contributes one bit of data to the solution of the general problem topic. The textbook work is merely that of supplementing the knowledge gained by actual experimentation and takes the nature of reading rather than study although some time is spent in recitations proper. The readings are in part assigned and in part unassigned. The former are checked up by class recitation, the latter by written abstracts handed in, a minimum limit of ten pages per week being observed. In such a course, the textbook may be highly influential in the success of the work, but it is scarcely a vital element.

Digitized by Google

II. Immediate, Environmental Problems.

The second characteristic of the general science of the future grows out of the discussion of the preceding one. It is partly a criterion for the selection of subject matter of useful nature and partly a question of suitable method. It is only for the sake of emphasis that it needs further mention. The texts I have just cited illustrate something of what we mean by choosing materials which are correlated with the immediate surroundings and interests of the child. Admittedly far from perfect, each year has brought us nearer to the ideal. Caldwell and Eikenberry were the first to grasp the idea of environmental problems in contrast with formal laws and principles as the point of departure in the study of science. Later came Smith and Jewett, Van Buskirk and Smith, Hodgson, and last, Trafton, an advance copy of which I have brought here today for examination. There is nothing new in the method of these books—it is rather a question of a more extended use of a recognized pedagogical fact, viz., that everyday applications of scientific laws form better starting points than purely hypothetical applications of those same laws. The mystery is here the same as in other points that I have discussed, i. e., when everyone is agreed upon a thing, and we heatedly advocate it at every opportunity, *why don't we do it ? ? ? ?* Instead, we go ahead writing our books as we have always done. It looks suspiciously like the kiss of Judas and that we lack the courage of our convictions. Here, again, I believe that the recent textbooks in general science will gain rather than suffer by comparison with science texts in general.

III. General Science for Junior H. S. Grades.

This, like point one, is largely a question of administrative needs, but concomitant with these are certain deeper and more psychological relations of subject matter and method. With the growth of either the 6-3-3 or the 6-6 plan, there is to be a great need of science instruction through the grades 7-9 inclusive. Geography is finished in modern practice in about grade 6, or 7 at latest, leaving either two or three years without any comprehensive and unified science program. Agriculture and physiology receive a certain emphasis but are a disgraceful example of teaching science by ignoring all scientific procedure in their method of presentation. It is an open question whether such subjects can be considered a success in this position. There is,

Digitized by Google

therefore, an unfilled space in our science curriculum. The sciences of the senior high school are furnishing a pressure downwards with the special sciences of botany, physiography, biology, zoology, geology, physics, chemistry and physiology all clamoring for a place.

All this in addition to the fact that general science is in its psychological nature suited to adolescent years. Its concrete rather than abstract nature, its generalizations from immediate applications to the laws themselves, its bird's-eye view rather than the logical classificatory treatment of data, and the like, all serve to make general science the proper science for the junior high school. The expansion of the course over 2-3 years will surely follow as a matter of course, and in so doing will tend to eliminate another criticism of the subject, viz., its tendency toward superficialism due to its wide range nature. There will be less need to rush from one topic to another as some seem to think is necessary as if there were some divinely set goal to be reached by the end of the term, in contrast with a few things well taught. In the country school and rural high school, the science will be largely colored by the problems of the farm environment and life. This adaptability of general science to local needs is in reality a source of strength since it is free to conform to the community rather than be bound to follow a formal set of principles and experiments as in biology, physics or chemistry.

Lastly, general science should furnish aid to the junior high school movement to a considerable extent in that exploratory aim of this reorganized school unit which is so committed to vocational guidance.

There is little question that "problem" or "project" teaching is one of the leading questions in the field of methods of instruction today. Originating, perhaps, in the field of the social sciences, it became almost simultaneously a storm center in natural science. Thus far the problem or project has escaped definition, being concealed in a fog of theory and ideals in the camp of the educational theorists on the one hand and lying humbled and bleeding in the camp of the vocationalists on the other. The former would demand standards impossible of immediate attainment, the latter would degenerate the problem into mere pieces of handwork. A problem reduced to the operation of turning out a piece of wood on a lathe, or the like, surely offers little new to methods of teaching as this is almost uni-

Digitized by Google

versal practice in the manual arts. If there is such a thing as a problem and if it offers educational possibilities, it must present a series of psychological processes which bear a close relation to those nervous activities of creative thinking. In a phrase, the problem, if valuable and a new contribution, must involve the higher thought centers rather than the lower neuro-muscular functions. So much for a fleeting glance at the psychology of the project.

Another point of view is that of John Dewey. The five steps in the thought act of Dewey is virtually an analysis of the problem method as it appears psychologically. Like the preceding discussion I have given, Dewey's scheme offers little of directly practical value in getting problem teaching under way in our classrooms.

Somewhat more concrete is Snedden's attempt at formulating the evolution of the problem or project. He recognizes four stages, as follows:

1. The Question.
2. The Lesson.
3. The Topic.
4. The Project.

1. The question, the smallest unit ever devised, was partly pedagogical and partly logical in nature. It is the most easily used by the unskilled teacher and is best suited to the age of authority and memorization.

2. The lesson was a pseudo—pedagogical unit; being based upon the sheer physical learning capacity of the child. Hence, it largely measures duration of attention, fatigue effects, etc. It tends to be purely arbitrary as, e. g., like cutting off two yards of cloth or one hundred feet of rope.

3. The topic is characterized by some logical relation to some larger unit of subject matter. At the same time it takes account of the limit of the focusing of attention power of the child. It is more suited to inference and processes of reasoning than to memorization.

4. The project is characterized by concrete achievement, thus taking its unity. There is always a clearly forseen end to be reached and the process of reaching that goal must be objective enough to permit of evaluation. It calls for the application of past knowledges and skills together with the acquisition of some views, knowledges and skills. Even in the case of the project, while it is somewhat final from the pupils' standpoint, to the teacher it is a step to some larger goal.

Digitized by Google

From a biographical viewpoint, there is probably no better illustration of the problem method than that of the life of Pasteur. Starting out with a purely chemical problem in the stereochemistry of racemic acid, he studied successively crystallography, polarized light and rotation effect in solutions, the nature of fermentation, the liquor industry of Belgium, microorganisms, disease, etc., etc., in a brilliant series of projects covering a life time.

We have seen efforts at formulation of the meaning of the project from three viewpoints, the psychological, evolutionary and biographical. The general idea is fairly evident, the exact definition impossible, the application uncertain. Of the five characteristics of general science teaching of tomorrow, this is the most visionary, but perhaps at the same time the most promising. The literature on the subject is fairly extensive but falls sharply into two groups: (1) purely theoretical, (2) practical but falling far short of the ideal. A few textbooks like VanBuskirk and Smith have made a noticeable gain in this direction.

Before leaving the project question, it may be to the point to restate one thought previously mentioned, for the sake of emphasis. The project, whatever it may look like when viewed objectively, is intended to stimulate a certain sequence in thought processes—those usually termed the reasoning processes. This virtually reduces the psychology of the project to that of induction. The difference seems to be of a structural sort, more related to the content concerned in the development of a project, e. g., such matters as the ignoring of formal boundary lines of special science and the concrete, practical product produced incidentally to the play of those higher observational and inferential mind processes. To the writer's mind, the project is little more than a new cloak for the inductive method, but has a new value in that it is applied to concrete achievement rather than over-difficult abstract principles. Such concrete problems of the wiring of a door bell, or the dyeing of a doll's hair and clothing from coal tar products obtained in candy from the corner grocery store, are never chiefly valuable in themselves as a commercial matter, the practicability and concreteness being chiefly useful in that they form a means to strike the responsive chords in the child's thinking. It is for this reason that the problem method will continue to be explored and eventually form a most valuable instructional tool.

Digitized by Google

V. Standard Measurements.

As Professor Eliot R. Downing, of the University of Chicago, has pointed out in *School and Society* for November 15, 1919, science teachers, rather strangely, have been most loath to adopt the newer scientific methods of measuring results. This is without doubt a part of the conservatism demanded by scientific procedure.

The growth of standard tests is a feature of modern educational progress in many school subjects, although little, comparatively, has been done for high school subjects. A few beginnings have been made, notably the Starch test for physics, although this has not attained as much attention as it deserves. Grier has a range of information test for physiology and zoology, and Downing one for secondary science in general. F. T. Jones devised a test for physics and chemistry, and within the past year Hanor A. Webb and J. Carleton Bell have each attempted tests for chemistry. Lackey and Witham have tests for elementary geography.

General Science Quarterly for November, 1919, has an account of the writer's, "Range of Information Test in General Science," begun two years ago but interrupted by the war. A preliminary standardization of this last is now under way.

Conclusion.

In conclusion, it may fairly be stated that general science has demonstrated the right to further experimentation in our schools, and that the opposition to such courses is gradually dying out as the aims, methods, and results are becoming better known.

For the future, general science seems to have one chance, and perhaps only one chance, viz., its ability to work out a better method of instruction than the special science of the past has produced—a method that I have tried to characterize in five ways as involving:

I. Inductive, laboratory teaching.
II. Selection of materials to form environmental problems.
III. Junior rather than senior high school science.
IV. Project science.
V. Use of standard tests.

Digitized by Google

THE CHARACTER OF THE ROOTS OF A QUADRATIC EQUATION.

By Robert E. Moritz,

The University of Washington, Seattle, Wash.

It is the universal custom of English and American writers on algebra, including such eminent writers as Chrystal and Todhunter, to discuss the character of the roots of the quadratic equation $ax^2+2bx+c=0$, by means of the discriminant b^2-ac. This function conveniently distinguishes equations having real roots from those having complex roots and singles out the case in which the roots are equal, but it fails to indicate cases in which the roots are numerically equal and opposite in sign, or when unequal and of like or opposite signs, or when both roots are purely imaginary, or when one or both roots are zero.

Certain European Continental writers[1] do indeed consider some additional characters after the theorems relating to the connection between the coefficients and the roots of an equation have been established. The additional characters are then derived by considering simultaneously the signs and absolute values of the ratios c/a and b/a in conjunction with the sign of the discriminant. Bourlet tabulates the following cases:

[1] *Borel, Algebre 1er Cycle* (Paris, 1905).
Bourlet, Precis d'Algebre (Paris, 1907).

$c/a < 0$ two roots with opposite signs	$-b/a > 0$,	root with largest absolute value $+$.
	< 0,	root with largest absolute value $-$.
	$= 0$,	roots equal and opposite in sign.
$c/a > 0$	$b^2-ac > 0$, $-b/a > 0$,	both roots positive.
	< 0,	both roots negative.
	$=0$,	each root equal to $-b/a$.
	< 0,	no real roots.
$c/a = 0$	one root $= 0$, the other root $= -2b/a$.	

Now all these results, besides some others as will be shown, may be easily obtained without the assistance of any preliminary theorems from the character of the function ac/b^2. This function so completely determines the character of the roots of the quadratic that it might be appropriately called the *characteristic* of the roots of the quadratic. As this characteristic varies from $-\infty$ through all real values to $+\infty$ the roots of the quadratic assume in succession all possible characters, that is to say, to each character of the roots corresponds a definite value, or range of values, of the characteristic.

Let us write the quadratic in the form

$$ax^2+2bx+c = 0,\ a > 0, \tag{A}$$

Digitized by Google

from which

$$(B) \qquad x = \frac{-b \pm \sqrt{b^2 - ac}}{a} = \frac{-b}{a}(1 \mp \sqrt{1-k})$$

where $k = ac/b^2$.

1. $k = -\infty$. Since a is positive, b must be zero and c negative. Then (A) shows that both roots are real, numerically equal, and opposite in sign.

2. $-\infty < k < 0$. Since k is negative, $1-k$ is positive and greater than 1, therefore $\sqrt{1-k}$ is positive and greater than 1, therefore one value of $1 \pm \sqrt{1-k}$ is positive and the other negative. The roots of the quadratic are therefore real, unequal, and opposite in sign, the numerically greater root being positive or negative according as b is $<$ or > 0.

3. $k = 0$. If $k = 0$, $\sqrt{1-k} = 1$, hence one value of x is 0 and the other is $-2b/a$.

4. $0 < k < 1$. $1-k$ is now positive and less than 1, therefore $\sqrt{1-k}$ is positive and less than 1, and both values of $1 \pm \sqrt{1-k}$ are positive. The roots of the quadratic are therefore real and have like signs. They are both positive or both negative according as b is $<$ or > 0.

5. $k = 1$. If $k = 1$, $1-k = 0$, and (B) shows that x has two equal values each equal to $-b/a$.

6. $1 < k < +\infty$. In this case $1-k$ is negative, therefore $\sqrt{1-k}$ is imaginary and the roots of the quadratic are complex.

7. $k = +\infty$. This requires that c be positive and $b = 0$. From (A) it appears that the roots are then purely imaginary with opposite signs.

8. $k = 0/0$. If k is indeterminate in form, both b and c must be 0. (A) shows that in this case both roots are equal to zero.

The foregoing results may be exhibited graphically as follows:

roots real equal opp. signs $x_1 = +Q$ $x_2 = -Q$	one root zero $x_1 = 0$ $x_2 = -2b/a$	roots equal $x_1 = -b/a$ $x_2 = -b/a$	roots imaginary conjugate $x_1 = +iQ$ $x_2 = -iQ$
roots real unequal opp. signs $x_1 = P+Q$ $x_2 = P-Q$ $\lvert P\rvert < \lvert Q\rvert$	roots real unequal like signs $x_1 = P+Q$ $x_2 = P-Q$ $\lvert P\rvert > \lvert Q\rvert$	roots complex conjugate $x_1 = P+iQ$ $x_2 = P-iQ$	roots equal zero $x_1 = 0$ $x_2 = 0$
$-\infty < k < 0$	$0 < k < 1$	$1 < k < +\infty$	
$k = -\infty$ $k = 0$	$k = 1$	$k = +\infty$	$k = 0/0$

PRODUCTION OF ALUMINUM IN 1919.

The value of the primary aluminum produced in the United States in 1919, according to reports received by the United States Geological Survey, Department of the Interior, was $38,558,000 as compared with $41,159,000 in 1918. This decrease of $2,601,000 was probably due to a curtailment of production in 1919, forced by the accumualtion of large stocks of aluminum by both the government and the manufacturers in 1918. The market prices quoted during the first four months of the year were lower than those which prevailed during the remaining months, and apparently most if not all of the stocks were taken by the beginning of the last quarter.

Digitized by Google

PLUS AND MINUS SIGNS IN ALGEBRA.

By Jos. A. Nyberg,
Hyde Park High School, Chicago.

The beginner in algebra is always confronted with the necessity of learning the double significance of the + and − signs. They are signs of the operations of addition and subtraction,.and also signs of quality, positive and negative. In the language of grammar they are both verbs and adjectives. In reconciling these two views, we either must make elaborate explanations, or else attempt to dodge the trouble by omitting any reference to it. The present paper explains a mode of treatment of this difficulty.

After the pupil has been shown the existence in nature of both positive and negative numbers, the signs + and − being used as signs of quality or adjectives, we consider the question of addition. In adding a column of three or more numbers the teacher calls attention to the fact that the list of numbers may as well be written in a line instead of in a column, the numbers being separated by commas, as $+17$, -6, -13, $+5$, -18, just as we find similar problems stated in arithmetic. However, inasmuch as the signs separate the numbers so that 17 and 6 cannot be interpreted as 176, the commas may be omitted. This omission was impossible in arithmetic unless we in some way spaced the numbers. In other words, algebra needs no sign for addition. *Addition is to be understood as long as no other operation is indicated.* When handling polynomials also we may eliminate the need of a sign for addition by adopting a new attitude toward parentheses.

Consider the expression $3(2a-5)$. Instead of saying that the parenthesis is a symbol for grouping of terms, we say that the presence of a parenthesis should always suggest multiplication, i. e., a quantity in a parenthesis should always be multiplied by the quantity preceding it. Hence $-3b(2a-5b)$ is a problem in multiplication, the multiplier being $-3b$. And $3a(5a-3b)-3b(2a-5b)$ is a problem in two multiplications, followed by the problem of addition. The pupil should not think of this as a problem in multiplication followed by a substraction, for the $-$sign is an adjective qualifying $3b$ and is not a verb. The addition follows the multiplication because no other operation is indicated.

When a quantity like $-3(2x-y)+(-3x+2y)$ is met, I explain to the class that if no multiplier is present before the paren-

Digitized by Google

thesis, the number 1 is understood and the problem means $-3(2x-y)$, $+1(-3x+2y)$. This is consistent with previous experience for we write a letter x when we mean $1x$, and write $-x$ meaning $-1x$. Thus $4(2x-3y)-(6x-y)$ means that $6x-y$ is to be multiplied by -1 and added to the result of the other multiplication.

Let us see what changes in the order of the exercises this new attitude toward a parenthesis will involve. Regarding the parenthesis in the old way as a symbol for grouping, the pupil first learns to remove parenthesis from such an expression as $(3x-y)-(6x-8y)$ and is later taught that $3(x-2y)-2(x+6y)$ means $2x+12y$ is to be subtracted from $3x-6y$, and the teacher must avoid single expressions like $-6(2x-3y)$ because the pupil will want to know from what he is to subtract the $12x-18y$. Note how many different explanations are necessary. But using the new definition of a parenthesis, all these problems are of one kind, problems in multiplication. The teacher should reverse the order illustrated and consider first, quantities like $-6(2x-3y)$; second, $-6(2x-3y)\pm 2(x-7y)$ as this uses addition after the multiplications; third, quantities like $(3x-2y)\pm(6x+8y)$ where the invisible number 1 is understood.

Having eliminated the $+$ sign for addition, the $-$ sign for subtraction can also be dispensed with. We begin as usual by explaining that subtraction in algebra does not mean what is left after something is taken away, but involves finding what must be added to the subtrahend to obtain the minuend. The writer has always found that this can be done easiest by using equations, a subject which is usually begun fairly early in the course, and should be available when subtraction is reached. Thus, let $x=$ what must be added to -6 to obtain 10. Arrange several problems on the blackboard in such a scheme as:

Subtrahend	-6	$+5$	-7
Minuend	$+10$	-3	-2
	$-6+x=10$	$5+x=-3$	$-7+x=-2$
	$+6 \quad =+6$	$-5 \quad =-5$	$+7 \quad =+7$
	$x=16$	$x=-8$	$x=5$

Then ask: "What was added to each member of the equation? What was added to the minuend in each problem?" This analysis is easier to understand than why the loss of a debt is the same as the gain of an asset, etc. The pupil sees that subtraction involves two steps, the multiplication by -1 followed by an addition. Hence no sign for subtraction is ever necessary.

Digitized by Google

Wishing to subtract $6x-7$ from $3x-9$ we write $3x-9-(6x-7)$ meaning $3x-9, -1(6x-7)$ the comma and the one being omitted according to custom.

Thus the verbs + and − are eliminated from our grammar; only the adjectives + and − remain.

The usefulness of this attitude toward the + and − signs and parentheses can be seen in simplifying such an expression as $3(a-2b)(4a-5b)-5(2a-b)(a+4b)$. This would be done as follows: it equals

$$\begin{aligned} &3(4a^2-13ab+10b^2),\ -5(2a^2+7ab-4b^2) \\ &= 12a^2-39ab+30b^2-10a^2-35ab+20b^2 \\ &= -2a^2-74ab+50b^2. \end{aligned}$$

Again in later work, the pupil would be taught that the equation $(3x-7)/6 - (2x+6)/3 + 2(x-6)/5 = 0$ should be regarded as $^1/_6(3x-7),\ -^1/_3(2x+6),\ +^2/_5(x-6) = 0$ and then as $5(3x-7)-10(2x+6)+12(x-6)=0$.

THE DISMAL SWAMP OF VIRGINIA AND NORTH CAROLINA.

Few regions in America are more adorned by nature or more interesting to the tourist and scientist than the Dismal Swamp of Virginia and North Carolina. Though the entire region may present a dismal appearance in winter and some parts of it in all seasons, the swamp is annually visited by many pleasure seekers and has long been a place of study and absorbing interest to the geologist, the botanist, and the zoologist. It lies in the Coastal Plain of Southeastern Virginia and Northeastern North Carolina. Most of the surface consists of recently formed peat, the residuum resulting from the arrested decomposition of vegetation, but the underlying rocks are older and record events that occured thoussands of years ago, in the pleistocene epoch. The peat ranges in depth from one to twenty feet. Contrary to popular belief this peat has antiseptic and preservative properites, and consequen ly much of the surface water is pure. Though no remains of primitive man or of extinct animals like those uncovered in the bogs of Ireland have been found in the Dismal Swamp, the peat contains many well-preserved trunks of cypress trees that lived long before America was settled by our ancestors.

The region may be readily reached from Norfolk by canals, whose banks, shaded by stately trees and graceful vines, afford an ever-changing scene from the deck of the little steamer that daily plies their waters. When the swamp was young it was entirely covered by water, but much of the water has drained off through these canals, and large areas are now dry. In the center is a picturesque body of water called Lake Drummond, the origin of which is a mooted question. According to the most plausible hypothesis that has been advanced, it is the remnant of a large body of deep water which once covered the entire region. The water in this lake, because of its remarkable keeping property, was used in earlier years for drinking on trans-Atlantic voyages. It is amber-colored and is known locally as "juniper water." As the name implies, the peculiar color has been ascribed to the bark of the white cedar (juniper), which abounds in the swamp. It seems more likely however, that this color is given to the water by its finely divided vegetal content or by the dye extracted from the brown peat.— *U. S. Geol. Survey.*

Digitized by Google

THE CLAIMS OF MATHEMATICS AS A FACTOR IN EDUCATION.[1]

By Professor C. N. Moore,
The University of Cincinnati.

It is perhaps needless to state before this audience that the subject assigned to me is a large one, and that it would require several volumes to treat it in detail. In order to confine myself to the limitations of a brief address, it becomes necessary then to make certain restrictions as to the scope of the discussion not suggested in the title. In the first place I shall confine myself to the field of general education as distinguished from the fields of special education, such as vocational, professional or technical education. And in this particular field, by no means a narrow one, I shall consider only certain broad aspects of the question.

Before deciding on what is important in general education, it is necessary to define with some precision the proper aims of such education. In the absence of any general agreement on this question, I offer the following definitions as expressing my own ideas on the subject. It should be understood that in these statements I am restricting myself to the education of the mind, thus expressly excluding physical or moral education.

First of all, general education should lead to a thorough acquaintance with certain facts and ideas of central importance, about which the existing body of human knowledge is grouped. It should further develop the ability to use these ideas and facts in their own and related fields. In the second place, such education should furnish a well-rounded mental discipline, obtained by properly proportioned efforts in each of the various fields of mental activity. Lastly, it should give to the student a certain intellectual culture, which may be defined as the appreciation, in a broad sense, of the most important elements in the general scheme of modern civilization.

This is an ambitious program of course, and it is too much to expect that it can be fully completed in each individual case, but it seems to me to be the proper ideal toward which we should strive, and I believe it is at present realized in a large measure by the best of our students in the best of our schools. At any rate, if education is to be improved, we need to set our standards higher than the average level of current practice. So I feel no hesitancy in basing my discussion of the importance of mathe-

[1] An address delivered before the National Council of Mathematics Teachers at the meeting of the National Education Association in Cleveland, Ohio, Feb. 24, 1920.

Digitized by Google

matics in general education upon the above statement of the proper aims of such education.

Among the ideas and facts of central importance, in our modern civilization, we must obviously list the properties of number and space. Precise ideas about almost anything in the universe involve to some extent these properties, and the bulk of our scientific and technical knowledge involves them to a considerable extent. It is no accident that mathematics was the earliest of the sciences to develop. The human race could make no progress in other fundamental sciences, such as astronomy and physics, until it had investigated the elementary relations of number and space. It could not properly attend to many other matters of a more immediate practical application, such as the measurement of time, the division of land, the erection of buildings, the conduct of commercial transactions, without the results of certain mathematical investigations.

Although the science of mathematics appears to have originated under the urge of practical necessity, it was not long before mankind developed a keen interest in the development of mathematics for its own sake. The conceptions of number and space as used in mathematics are creations of the human intellect, abstractions from our sensory experiences which transcend the limitations of the senses. Hence, in working with these conceptions we reach a precision of results unattainable in other fields of investigation and which has furnished a peculiar satisfaction to some of the world's greatest intellects. It is fortunate for the progress of civilization that this is the case. Some of the most important discoveries in other fields would never have been made, or else would have been long postponed if certain mathematical theories had not been previously studied for their own sake. For example, Greek mathematicians studied the properties of the conic sections because these properties constituted a beautiful and harmonious theory in the field of pure mathematics, which aroused their highest admiration and interest. Centuries later, the mathematical astronomer, Kepler, was able to discover the laws of planetary motion because he knew about the properties of conic sections. The discovery of the calculus by Newton and Leibnitz was the culmination of a long series of advances by themselves and their predecessors in the field of pure mathematics. Because of this discovery, Newton was able to verify his hypothesis with regard to gravitation and thus establish one of the most fundamental laws, with regard to the

Digitized by Google

universe in which we live, that has yet been discovered. The invention of wireless telegraphy may be traced back in a direct line to certain investigations in mathematical physics made by Clerk Maxwell. These are only a few illustrations of the important role that mathematics has played in human progress.

The very brief account I have given of the contributions of mathematics to the development of our modern civilization is sufficient to show that some understanding of mathematics is necessary for even a superficial acquaintance with the nature of that civilization, and it goes without saying that this knowledge should include more than the technique of arithmetic. For practically none of the applications of mathematics in science, in technology, and in certain commercial fields, can be understood by one whose knowledge is limited to arithmetic.

I think it ought to be clear, then, that the elements of algebra and geometry must be classed among those central ideas which should certainly be included in general education. Furthermore, they should be placed as early in general education as the maturity of the student will permit, on account of their usefulness in other fields of knowledge, such as the natural sciences. The more elementary notions of trigonometry and analytical geometry ought to be included in the mathematics for general education in place of some of the topics now taught in algebra and geometry. I would make this substitution on the basis of my formulation of the aims of general education. For the trigonometric functions and graphs are ideas of more central importance than the finesse of algebraic technique and the proof of one intuitive fact in geometry by means of other intuitive facts.

I have now justified the inclusion of mathematics in general education from the standpoint of the first of the three aims of general education that I have formulated. Let us consider the second aim, namely, the securing of a well-rounded mental discipline. I know there are certain professional educators who see red when the terms "mental discipline" or "general training" are mentioned, but practical men of affairs and people in general who are doing the important work of the world agree that a proper system of general education contributes something to the development of the individual which we must needs call by some such name. In this connection the following brief quotation from Admiral Sims' interesting story of "The Victory at Sea," is particularly pertinent: "I have even been inclined

Digitized by Google

to suggest that it would be well, in the training of naval officers in the future, to combine a college education with a shorter intensive technical course at the Naval Academy. For these college men have what technical academies do not usually succeed in giving, a general education and a general training, which develops the power of initiative, independent thought, an ability to grasp quickly intricate situations, and to master in a short time almost any practical problem. At least this proved to be the case with our subchaser forces." As the use of an education in the conduct of important practical affairs ought to be a better test of its value than experiments on the crossing out of letters on a page, or the guessing of weights and magnitudes, I should not hesitate to use the term mental discipline until some one suggests a better one to express such concrete results of a good general education as have been noticed by Admiral Sims and other observant men who are engaged in directing important and difficult tasks.

We are to consider, then, whether or not mathematical training is essential in securing a well-rounded mental discipline. Since we have already pointed out that properties of number and space are of such fundamental importance in almost all phases of civilization, it ought to be evident that a well-rounded mental discipline cannot be secured without a considerable amount of study of such properties. This is entirely aside from the value of mathematics as a training in logical thinking, the discussion of which would carry this paper beyond proper bounds.

We come finally to the third aim of general education, namely, the securing of a certain intellectual culture. In this connection I do not hesitate to assert that no one can have even a cultural appreciation of the nature of this highly technical and scientific age in which we live without some knowledge of mathematics. If the time permitted, many facts might be adduced in support of this statement. As it is I shall limit myself to a very few interesting and pertinent ones that were pointed out several years ago by Professor S. G. Barton of Flower Observatory. Professor Barton enumerated the titles of 104 articles in the eleventh edition of the *Encyclopaedia Britannica*, in the course of which the symbols of the calculus were used, Only about a fourth of the headings are those of pure mathematics, and the list contains such titles as bearings, bridges, clock, gravitation, heat, lens, lubrication, map, molecule, power transmission, shipbuilding, sky, steam engine, strength of materials, sun, tide, and measure-

Digitized by Google

ment of time. If the elementary notions of algebra and geometry had been made the basis of selection instead of the use of the symbols of the calculus, the length and scope of the list would have been vastly increased. Does anyone need any better objective proof of the necessity of the study of elementary mathematics, in order to arrive at a cultural appreciation of present day knowledge?

TALC AND SOAPSTONE INDUSTRY.

United States is Largest Producer.

America leads the world in talc and soapstone industry, not only in production but especially in manufacture and use. The output of talc in the United States sold in 1918, according to J. S. Diller, of the United States Geological Survey, Department of the Interior, was 191,477 short tons, having an average value of $10.91 a ton. This was a decrease of about 7,000 tons in production as compared with that of 1917 but an increase of more than $200,000 in value.

Talc was not considered a war mineral and its production was retarded by the war, but the spread of knowledge concerning its uses and its usefulness has stimulated the talc industry. Its more general use has been promoted by the formation of a talc and soapstone producers' association of which Freeland Jewitt, of Boston, is president.

Vermont produces the largest quantity of talc, but the output of new York is of greater value. California ranks third in quantity and value and, notwithstanding the general decline in production elsewhere in the United States in 1918, it more than doubled its output of 1917. California produces some soapstone, but the bulk of its production is ground talc, mined in Inyo and San Bernardino counties, where it is more or less intimately associated with limestone and in part possesses a fibrous structure similiar to that in much of the talc of the Gouverneur region, New York.

The United States produced about 58 per cent of the world's output of talc in 1918 and in addition imported more than 11 per cent of all the talc produced by the rest of the world. As little if any talc was exported, it is evident that the United States is preeminently a consumer of talc. Canada is the only competitor for the domestic trade in middle-grade talc. About 12,000 tons, 96 per cent of the talc imported in 1918, came into the United States from Canada.

The United States is well supplied with low and middle grade talc but lacks high-grade material for use in toilet powder, electric insulators, and gas burners, commonly called lava tips. The talc used for such purposes is imported mainly from Italy and France and, through other countries, from India.

Within the last two years a new and interesting source of talc has been found in a large dike of surpentine in Harford County, Md.

Virginia is the only great producer of soapstone in the world, shipping more than 15,000 tons in 1918. The production has, however, declined irregularly for the last ten years. Soapstone is one of the rocks that are most widely useful to primitive peoples, who on account of its softness, resistance to sudden changes of temperature, and slow radiation of heat, employ it chiefly as "potstone"—that is, for making pots. We make a similiar use of it in soapstone stoves, foot warmers, and disks for fireless cookers, although in this country it is used principally in laundry tubs, laboratory tables, hoods, and sinks.— *U. S. Geological Survey.* ...

Digitized by Google

SOME APPLICATIONS OF THE PROJECT METHOD IN HIGH SCHOOL MATHEMATICS.

By Edith St. John Eaton,

Berkeley, Calif.

If one judged the perfection in the teaching of a subject by the length of time in which it has been studied, then perfection in mathematics might be expected, after having been taught for centuries. The real fact is that only very recently have teachers varied to any marked degree from the old Greek geometer, Euclid. Mathematical thinking did not originate with mathematicians nor was it recorded by mathematicians but it originated with philosophers, and these men thought in general terms. If one will look over the list of Greek mathematicians he cannot but be impressed by the fact that they are also the men who ranked high among the list of philosophers. What was true in earlier times is just as true in the seventeenth century. D'Alembert Descartes, and Leibniz are equally great in philosophy as in mathematics. The difficulty for us arises when we realize that these philosophers put down their conclusions in logical order often far from the order in which they reached these conclusions. As a result we have many generalizations. We, so far, have proceeded on the theory that once a pupil gets these generalizations, he will be able to use them. We have found however that a very high average of students are themselves unable to see the application of the generalization or often cannot apply it when it is pointed out to them. In this very fragmentary way, I have endeavored to answer the question, "Why is it necessary for us to find a new method in mathematical teaching?" In this paper I hope to examine the project method as one solution.

What is a project? "The project is a motivated problem, and, as such its solution requires thought, its completion results in the production of something of value to the student. It is always concrete, since children's sense of values comes largely from commercial sources; it follows that a school project is judged by business standards, the appropriate method of solution is that of commerce, the tools and the materials used in the solution should be adapted to commercial production; the project is a small sample of real life brought to school; it is adapted to the development of traits required for a successful vocational career." The quotation is from J. A. Randall of Pratt Institute and might imply perhaps that the project method is especially useful in mathematics. It may be, but if so, the literature on the sub-

Digitized by Google

ject is yet to be written. The reference desk of one of our largest universities reported that they did not find one book, article, or pamphlet written on the subject. The material presented is not a compilation of other people's projects, but a statement of a few ways that I can see its application in high school mathematics.

Certain University schools have worked out projects in arithmetic for their Junior high schools. I have in part tried this myself; such as a class in mensuration building a house. From the time the lot is purchased, through the stages of drawing the ground plan, excavating, removing the dirt, mixing the cement, laying the joists, building the walls and even to the hanging of the stenciled curtains in the individual's bedroom, each child proceeds. With one class it is an individual project; and, in another, it is a group project, according to the desire of the teacher. In the former case, every child works out the amounts of materials and costs for his individual "house beautiful"; in the latter, some opportunity is given for choice of work, although eventually every child has had experience with the various steps involved in the project.

In Monroe's *Cyclopedia of Education*, I found this statement, "Efforts to find commercial or scientific applications of topics like factoring, quadratics, or radicals have not been very successful; the immediate interest in these subjects must be found in the mathematics involved, in the game element, in the assurance that the work is necessary preparation for both pure and applied mathematics." I agree with the author in those particular phases of the algebra. However, there is one project which is quite commonly used in algebra. No argument is necessary to convince people today that the graph is a part of every general culture course. One can scarcely pick up a daily paper or magazine in which there is not a graphical representation of some data. One must have graphs to master physics successfully, chemistry, mechanics, economics, or meteorology.

There are only two project graphs which I endeavor to develop, from material already worked out; health, trade, or census reports, geography, interest tables, and secondly, from material which the pupils themselves collect, such as the fluctuation on the market of any commodity (one graph handed in was on the prices of eggs for the current year) others, weather reports taken hourly, deaths from influenza in comparison to other infectious diseases. The construction of practical graphs is an individual project.

Digitized by Google

J. W. A. Young in his text on the teaching of mathematics gives an illustration of what I consider could be used as a group project. If the daily profits of one or two factories are three dollars per workman less a fixed operating charge of eight dollars per day and the second factory makes five dollars per day but its fixed operating charge is twenty-four dollars per day, represent the net profits of each factory according to the number of workmen. For what number of workmen will the first factory make the larger profit? The second? For what number of workmen will they make the same? What is this profit? Very slow development and considerable thinking is required to have each individual grasp clearly the idea of an equation in two unknowns, each variable, and the "graph as recording a restriction to which these variables are always subject in their variation, and that the curve is the representation of their variation under this restriction."

My projects in plane geometry consist first in endeavoring to use motion or any other aids which will help to convince the adolescent mind that what is asserted is fundamentally true. A group project consisted in using yardsticks upon the floor to form a convex polygon. By carefully placing the rulers so that the exterior angles were produced in succession, one student was told to walk through the exterior angle at that corner and also for each successive corner. Eventually he reached the starting point and realized that he had made a complete turn or had passed through the angular space about a point. In the case in question practically every member of the class also came to the same conclusion.

The following individual project in plane geometry was tried: At the conclusion of the work on parallelograms in the beginning course and of circles in the second half of the work, I asked them to reproduce a design in which the decorator or the architect used an application of his knowledge of that part of the material we had just completed, to produce a decorative or working design. Filing cabinets, friezes, designs for wall paper, oilcloth, linoleum and patterns from Italian pottery were executed with real care. One girl drew the home library in perspective which illustrated all the figures so far studied.

Later projects were the measurement of the height of the school building and of the flag pole, the distance between two points which were themselves accessible but which were separated by some objects which prevents direct measurement by a line

Digitized by Google

connecting them. Plane geometry is a series of projects—hardly a lesson but what there is presented a problem whose solution requires carefully built proof in order to establish the truth of a given statement. Professor Kilpatrick, of Columbia, in his article on the project method would include originals in geometry under his third class, "Where the purpose is to straighten out some intellectual difficulty."

My object in using projects outside the regularly assigned task is not to divert the pupil from the main reason for studying geometry, ability to do real reasoning, but only to round out his school experience by a glimpse into extra-school experience and show him more clearly the need for pure mathematics.

In solid geometry, I have used individual projects only. I will give three illustrations; two were models which would prove to each individual the truth of such a statement as: "Through a given external point, there can be drawn one line perpendicular to a given plane and only one." And also the theorem, "The volume of any parallelopiped is equal to the product of the base by its altitude." The third was to determine which are the five regular polyhedra and why it is impossible for there to be more than five. The models were made individually and brought to class. Comparison with the other models brought about a quick recognition that there had been a failure to comply with the conditions imposed.

In trigonometry, one has more nearly ideal conditions for the application of the project method than in any other high school mathematics. The tools being acquired, there are real live projects which pupils can solve—the length of an unbored tunnel, the height of an aeroplane if observed from two points on the ground and in the same vertical plane with it.

Whenever the project method is used, its value is determined by the value to the student himself, secondly, by its usefulness to the other members of the class as a record of useful information, and as a third value, the skill obtained by the project will be, not only of present worth but of ultimate value in solving other projects.

De Garmo in his *Principles of Education* says, "the need for a laboratory for mathematics is as crying as a laboratory for science. In the latter it is a crying necessity. The literature economics, and history classes have the library as their form of laboratory. The mathematics workroom is a formal recitation room." I can partially agree with this statement but it seems to

Digitized by Google

me that we can bring the outer life into touch with the inner life of the school through some definitely arranged projects.

The project method developed in a laboratory is one leading from the concrete to the abstract, it emphasizes the doing, it requires a student to accomplish something within his capacity, and brings the applications of mathematics into prominence and does help him to clarify his notion of space concepts. But, in view of all this, I cannot but feel that it has several detrimental features. It is not easy nor is it always wise to make students discover all mathematical facts by experiments. Life is made up of occasions where we cannot reach our conclusions through our senses. Such work is liable to degenerate into a form of hand work, not head work; it is based on a wrong assumption that pupils cannot comprehend and thoroughly enjoy demonstrational mathematics. Projects give very little training in true mathematical thinking; the student gets mathematical facts but not mathematical reasons.

The project method can be a valuable supplement to the teaching of mathematics but it requires skill if its results are commensurate with the time involved. Original thinking is what I hope to generate by my mathematical teaching, and projects advisedly used can and do contribute to that end. We want power, not knowledge, in mathematics and must justify the applications of any method by firmly believing that it fulfills one of the ideals of mathematical teaching.

BIBLIOGRAPHY.

William H. Kilpatrick, "The Project Method," *Teachers College Record*, September, 1918.
J. A. Randall, "Project Teaching," *N. E. A. Proceedings, 1915.*
School and Society, 4: 419-23. Also 8: 487-490.
J. W. A. Young, *The Teaching of Mathematics.*
Schultze, *Teaching of Mathematics in the Secondary Schools.*

ARSENIC IN 1919.

The domestic production of arsenic in 1919, according to estimates compiled by James M. Hill, of the United States Geological Survey, Department of the Interior, was 5,000 short tons, as compared with 6,400 short tons in 1918.

The imports of arsenic for the first nine months of 1919, as reported by the Bureau of Foreign and Domestic Commerce, Department of Commerce were 1,389 short tons. The imports for the year will probably amount to about 1,550 short tons. Most of the imported arsenic came from Canada and Mexico, though some came from Belgium and Japan.

The quantity of arsenic available for consumption in 1919 was about 7,450 short tons, as compared with 7,170 short tons in 1918. There were no exports either of foreign or domestic arsenic during the first nine months of 1919.

Two domestic companies who produced considerable arsenic in 1918 reported to the Geological Survey that they produced none in 1919 on account of low prices.— *U. S. Geological Survey.*

Digitized by Google

AIR CONDITIONING IN SCHOOL BUILDINGS.[1]

By S. R. Lewis,

Consulting Engineer, Chicago, Ill., 910 So. Michigan Ave., Chicago.

Revolutionary discoveries of basic importance are extremely rare. The art of ventilation has received much study by rather competent people during at least fifty years, and there has developed a general practice covering fundamental principles which I am very sure should not be lost sight of. There are, these days, many opportunities to take up new schemes, but the old principles must not be violated if we are to hope for any improvement.

The lungs may be considered as mere bags, lined with a material well designed to prevent any infection. In fact, authorities say that air cannot carry from the lungs of one person to another person in ordinary human contact any harmful thing, infection being almost entirely by mouth or broken skin. The lungs have a very small air capacity compared with the amount of fresh air we have been accustomed to furnishing; they are worked to capacity only a very small part of the time; the passages and tubes leading to them always hold their contents of air which must be rebreathed at each inspiration, so that the fresh air actually taken in and discharged each minute amounts to not more than .25 of a cubic foot.

We do not know what the poisonous or harmful quality of expired air may be, if there is anything harmful in it. It is clear, however, that whatever it may be is not recognizable by any of our senses, and that whatever objectionable thing there may be in the air, of which our senses acquaint us, could hardly have been put there by contact with anyone's lungs. Further, the condition of the air inspired, aside from its temperature, is of little moment, so long as it does not carry infected dust or drops of water (which may possibly cause trouble).

The temperature of the air seems to be important as Nature, by the inexorable provision for mixing the fresh air with the already warmed air in the passages, insures that it shall not be too cold. Anyone who enters a refrigerated space in warm weather experiences the feeling that he can breathe more easily, that perhaps less air is required, though there may be no chemical difference.

[1]Read before the General Science Section, Central Association of Science and Mathematics Teachers, at Lake View High School November 28, 1919.

Digitized by Google

The skin is an admirable servant. It prevents the entry of infection unless broken. It is impervious to all chemical conditions of the air encountered in ordinary life. The temperature at the skin, however, is of vital importance to the party inside the skin. Nature has given us an elaborate mechanism for controlling this temperature, which depends for its functioning on the presence of moisture in the air and on movement of the air.

As far as we know, therefore, within the ranges of air as ordinarily encountered in life, neither as to lungs or skin, does it very much matter what chemical condition the air is in, and ventilation or air conditioning as far as it applies to schoolhouses means regulation of body temperature. As long as the air around the bodies of the pupils remains within reasonable limits of the optimum condition, the body functions will achieve the optimum without undue stress, leaving the mind free for highest educational efficiency. When the air gets too hot or too cold in its effect upon the skin, however, the body will originate a complaint; the pupil will become restless or sleepy, if not liable to weakening or infection.

It is not necessary, in order to experience the unpleasant effects of crowding or overheating, to be indoors. Similar conditions are often found in assemblages of people out of doors when there is no wind or where the topographical situation causes stagnant pockets. We seem to be most comfortable out of doors when in a gentle breeze, at a temperature slightly cooler than that of the body.

I believe that a schoolroom should have an arrangement of air supply which will rub over the bodies of the pupils in an appreciable current at such a temperature as not to cause discomfort. This temperature will depend on moisture and speed of movement, bearing a ratio to the room temperature. The temperature of the entering or moving air cannot safely be fixed, for entering air much cooler than the average room temperature inevitably causes discomfort. No great fear need be apprehended that the entering air may be too warm because in an occupied class-room the problem is nearly always one of cooling rather than heating. The floor must be warm enough to prevent cold feet. There is some evidence that when the feet are kept warm the balance of the body will endure a remarkably low temperature.

It is highly desirable to eliminate the local circulation or

Digitized by Google

short air circuits caused by hot radiators, cold glass and wall surface, and by cold air leakage in through walls and windows. If schoolrooms had double walls impervious to air, and double windows, not only would the heating problem be simplified and the cost much reduced, but also the ventilation would be much improved.

Where the air can be moved positively over the bodies of the people in a uniform current, the heating and ventilation are nearly always reported excellent. Such systems are possible at present in interior rooms having low ceilings, where inlets can be at one end, with outlets at the other end, giving a slow moving cross-draft, or in auditoriums where inlets can be under the fixed seats, with outlets at the ceiling giving a slow moving up-draft. If rooms are thoroughly heated prior to occupancy, and delicate temperature control is maintained and the volume is so great that the entering air need not be more than about ten degrees cooler than the warmest part of the room, downward ventilation is practicable.

One of the existing and much used systems of school ventilation introduces the fresh air, heated to an extent sufficient to overcome the chilling effect of glass and walls, say, around ninety degrees when it is zero outside. Another introduces it at about seventy degrees and compensates for chilling effect by direct radiators placed in the rooms.

Owing to physical limitations due to the exigencies of construction, with the first system the air cannot ever be introduced cooler than about sixty-five degrees, and with the second system the air goes everywhere at the same temperature, whether to a room crowded or empty, sunny or dark. The sixty-five degree limit of the first system is necessary to prevent drafts when the room temperature runs up due to the heat from the occupants or from sunshine. With the second system, overheating from the same sources, which are difficult to control, becomes even more common.

Both of these systems introduce the air horizontally overhead, and exhaust it at the floor. Of necessity, with both, chaotic conditions exist in rooms as to diffusion of the fresh air. All warm things, lights, radiators, bodies of occupants, sun-heated furniture, create upward currents of air whether fresh or stale, like miniature fountains. All cool things, such as windows and outer walls, cause downward currents. Some of these little circuits seldom change their content. Some stagnant

Digitized by Google

spots exist. An outsider may detect these spots by sense of smell on entering any schoolroom. When an occupant of such a room, who has been there some time, complains of closeness or oppressiveness, we can be sure that while it may be odorous he cannot detect the odor. What he feels is temperature, and nothing else. Lack of moisture or excess of moisture will evidence itself to him by sense impression of temperature. Increase of carbon dioxide may cause more rapid respiration, but even this will usually be indicated by a feeling of increase in temperature. If there is, however, an appreciable movement in the air within the room, so that he is swept over by a breeze, a very high temperature and a very rank odor will seem to the long-time occupant the finest of conditions.

There are many fads, fancies and fallacies about school ventilation, among them the one that by open windows the millennium may be attained. I have made careful tests over several weeks of a number of schools in which open window ventilation was being conscientiously operated. It was impossible to provide enough fresh air to control the temperature without creating objectionable drafts. The teachers could not be depended upon constantly to remember the windows, with the result that the rooms were many of them uncomfortably hot, then uncomfortably cold. The windward rooms received fresh air when the windows were opened, but the leeward rooms acted as vent flues for the windward rooms and received no fresh air at all. Every heated building has a neutral zone, above which pressure is outward; below which pressure is inward. The rooms below this zone received fresh air; those above it were vent flues for the lower rooms, and could not be kept cool. The direct inflow of dust was objectionable, and in every storm all intake windows had to be closed. Street noises were troublesome.

The unit system, whereby every room has a separate fan and heater, is entering into prominence though subject to nearly all of the objections of window ventilation, and being as yet even more crude than the older centralized types as to temperature regulation. The unit system is presumably adjustable by the teacher to compensate for varying wind conditions. The teacher will not and cannot pay much attention to outside wind conditions. No unit systems have yet been found which do not carry the same objections as the other systems, and they add some new complications of an electrical, mechanical and operating nature. They discharge the fresh air toward the ceiling

Digitized by Google

in front of the window, and exhaust it at the floor at an interior wall. One fad having some vogue entails an air washer, sealed windows, and recirculation of the air. No better distribution or temperature regulation is attempted. The air washer, when operated, will remove much dust, and some odors. It may promote some bacteria, though in all probability these will not hurt anybody. It is possible to operate such plants as this without running the air washers, however, and under such conditions, the plants become highly odorous as to their product, and temperature regulation becomes difficult.

It has been found most difficult to compel operating engineers to keep the air washers in clean condition, or to insure their continuous operation, since the building can be heated without operating the washers, saving power, fuel and labor. When there is little or no cooling surface in a room, such as single glass or exposed wall, the local heating surfaces, as radiators, may be omitted, and the air may be delivered with impunity directly across the rooms over the bodies of the occupants. The ventilation of such fortunate rooms is invariably unnoticed, or if noticed at all is called excellent, provided that the temperature control is good. Where fixed seats are available upward ventilation may be used, suiting the temperature of the entering air exactly to that of the occupants, and disregarding the losses of walls or glass. This also depends for its excellence on the efficiency of the temperature control, and requires considerably more elaboration of the control than is common in practice.

The last two types depend, it will be noticed, upon displacement, as compared with the other schemes, which operate by dilution.

I am willing to admit that ventilation by dilution is not ventilation at all. I believe that ventilation can be achieved only by displacement.

Temperature regulating devices have reached the stage where almost any desired refinement can be obtained, and we know how to build schools with hollow walls and double glass; and know that the fuel saving alone will pay the interest and sinking fund on the investment, to say nothing of the improved living conditions obtained. It should be possible with every scheme of ventilation, to open the windows whenever desired, to get the breezes in warm weather, or to stimulate the pupils with a cold snap for a few minutes occasionally in winter.

Psychologically, the first invitation for complaint about a

Digitized by Google

ventilating system comes from the mistaken instructions given by some ventilating engineers to the end that windows shall not be opened. In a properly constructed building we could introduce the fresh air at a temperature very close to that desired in the rooms, in a gentle breeze sweeping the room like a stream of water from a hose, even introducing it at the floor at one end of the room, removing it at the ceiling at the other end, perhaps introducing it at a tangent to the periphery of the room and removing it at the center, like a cyclone dust separator, causing a whirling breeze which should move all the air in the room all of the time.

All of these things have been done in schoolrooms, and successfully, on an experimental scale. These methods are common practice for theatres. In artificially cooled rooms air introduction is at the floor and removal is at the ceiling. Ventilation, which is simply removing excess heat, becomes rather simple when laws governing heat are followed. Do not hesitate to open the windows when it gets too warm. Excess temperature is a confession of weakness on the part of the design or operation of the plant in your building. The school is for the benefit of its occupants and overheating is harmful at other places than the coal pile.

Mechanical ventilation is indispensable. We cannot in any other way insure positive air movement. Local electric fans, to insure positive movement and breeze effect in existing rooms having an old fashioned air supply, will be found to be of great advantage. In new buildings the following are some of the features upon which advanced engineers are well agreed:

1. Mechanical ventilation, using plenum systems, that is with a supply fan pushing the air in. Exhaust fans for all toilet rooms, all interior rooms not having windows, all cooking rooms, all chemical laboratories, and other local sources of heat or objectionable fumes. Exhaust mechanical systems without supply fans have not been found efficient or satisfactory except possibly when a well designed fan arrangement having a separate fan for each room, combined with adequate temperature control and dust removal, is installed.

2. Heating arrangements such as will keep all plumbing apparatus and plants from injury by low temperature without running any fans.

3. Separate heating and ventilating units for each auditorium, gymnasium or other special room likely to be used at separate times.

Digitized by Google

4. Electrical operation of exhaust fans for toilets, special and interior rooms so that they may be ventilated in the warm weather of spring and fall when no heating is required.

5. All horizontal supply ducts are to be of sufficient size to permit access for cleaning, in general not less than 6 ft. high or 2 ft. wide, provided with electric lights, ample doors for access, and provisions for washing out with water or for vacuum cleaning.

6. If direct radiators are used in classrooms, they are to be so disposed or shielded as to prevent radiant heat from them striking the occupants.

7. All outside walls of the building are to be furred, with air space, and are to be of the warmest possible construction, preferably having a waterproof air-tight coating inside the brickwork. All windows are to be double, and weather-stripped. All outside doors are to have vestibules. There shall be a hollow attic space.

GENERAL SCIENCE AND VOCATIONAL EDUCATION.[1]

By PROF. A. W. NOLAN,

State Supervisor of Agricultural Education, Springfield, Ill.

First, last, and always we must consider vocational education as directly training for useful employment upon a productive basis. The Vocational Education Act is right in limiting its aim, so that the "controlling purpose of such education shall be to fit for useful employment." The advocates of vocational education have no quarrel with the friends of non-vocational education, nor should the latter criticize vocational education because it does not include in its aim the broad values of a liberal education. Each has its part to play in the educational program, each has plenty to do to look to its own field, and society needs the services which each can give.

It may not be clear to us all, as to which field general science belongs in our harmonizing of vocational and non-vocational education. To me it bears a vital relationship to both, and it is to this relationship I wish to direct this discussion.

In all vocational work, where manipulative or mental processes are required to carry on the vocation, there are three phases of instruction to use in following out a curriculum,

[1]Read before the section on General Science, Nov. 29, 1919.

Digitized by Google

They may be called the "three r's" of vocational education. rules, reasons, and related studies. In the consideration of any manipulative process of any of the vocations included under the Smith-Hughes Act, there are rules of procedure to learn, reasons and principles for the process to understand, and further related studies to make, in order to enrich or strengthen the content of the subject matter and practical results gained. To illustrate, suppose that the manipulative process to be taught were the addition of limestone in soil improvement. The rule of the process, briefly stated, would be, "Apply from two to three tons of ground limestone per acre upon land where needed, once in each four year rotation"; the reasons or principles involved, briefly stated, "Limestone corrects soil acidity, a condition unfavorable to plant growth. It also improves the physical condition of the soil." Further related studies may well lead to "a study of the history of the use of limestone in agriculture, some results at the various experiment stations, and the methods used."

While all three of the above aspects of the study are a part of the vocational methods to be used, the strictly vocational point of view would emphasize the first, or the rules of procedure, not only learned but carried out to assure skill in the manipulative processes. We would not stop here at the mere "rule of thumb." While this must be learned, vocational efficiency and progress require that the student pursue his training into the realm of reasons, principles and related studies. It is just here that general science may tie up at every point in vocational education, as a reference study, to give reasons, explain principles, and lead into related matter, for every manipulative process of all the vocations under the Vocational Education Act. The organization of the subject matter of general science, under this plan, is around the job, and its processes. We have scarcely time to be interested in the varying discussions of the organization of general science upon any other basis. A glance through one of the many general science books shows, as one topic, the "air as a substance related to animate and inanimate matter." In our study of vocational agriculture, when we are concerned with the manipulative processes of handling soil, feeding animals or plants, we shall refer to the subject matter of such a chapter to find our reasons and principles for such processes as are affected by air; and so on with water, light, heat, and the other common things and processes entering into the study of general

Digitized by Google

science, and the environment of the vocations. There may be much of the subject matter of our general science texts that can not well be considered as one or both of the "two r's" in the above plan of vocational instruction. I believe, however, that any of our standard general science texts may be used as a constant source of excellent reference material to give principles and enriching related studies for all the manipulative processes in the jobs of the major vocations.

I would not imply by this discussion that there is no other use for General Science except as a reference in curriculums of vocational education. Early in the courses, either in the junior high school or in the first year of the four-year high schools, general science should be a required study in all vocational courses. It should precede or parallel the vocational courses as a separate subject, for either one or two years. Speaking from an agricultural point of view, I favor two years of general science paralleling the first two years of vocational agriculture, and I hope that the leaders in vocational education and the leaders of science may soon get together on a program of general science that will strengthen and support our work in vocational education at every point, and thus enable us both to use our subjects for the highest service of the boys and girls whom we are training for useful, happy and efficient citizenship.

CLASSROOM SAYINGS.

What is smoke and how may it be prevented?

Smoke is caused by the carbon in the wood and it can be prevented by taking the carbon out.

What is a calorie?

Calone is a perfume which we get from the city of Calone in France.

Dew is the light-frost and is formed over night by the dampness. It is the light-frost that has not been frozen over.

Specific heat is the particular way molecules cling more closely together.

Gravitation is air pressure.

Dew is the evaporating of air or dew point.

Three ways of transmitting heat are: Concussion, confusion and friction.

Three ways of transmitting heat are curvilinear motion as sun's rays, rectangular, straight as heat from a furnace, and by pressure, put a pressure on rubber it becomes hot.

Three ways of transmitting heat are by earth, sun and plants when eaten.

The draft of a chimney is as follows: The chimney is open at the top, the pipes lead from the stove into the chimney where it is forced out into he air.

550 foot pounds is the power a horse uses every time he lifts one foot.

Digitized by Google

THE MATH QUEST.

By Helen Whitaker,
Topeka, Kansas.

Cast of Characters: Algebra; The Alphabet, twenty-six girls; *ten X's,* ten girls; *three −X's,* three boys; *Numbers 0 to 9,* ten boys wearing crowns with numbers in front.

Scene—An opening in the woods. (*Algebra enters.*)

Algebra—In sooth, I know not what the number is—
That subtle number, it eludes me still,
And how to catch it, find it, or come by it,
I know not. With this care I am distraught;
I've searched the woods to find the answer there.
I've peered in books for method, hint or guide,
And every disappointment makes me fear
Fortune doth mock my venture and withhold
The mystic number that the queen demands.
"Bring me the number, ere again you come
Whose square, when lessened by its seventh sum,
Is then worth naught." And I have failed!
But no, there's someone else I'll ask.
I'll call my letters forth to aid the task.

(*The Alphabet enters at her call.*)

O Alphabet, when last from all our realm
We met to crown a Queen, our Queen of May,
She gave to all her subjects some great task
To do for her. That was a year ago.
And now today I fain would greet her court,
But am forbid—my task's not finished yet.
For this I seek your aid. Thus spake the Queen,
"Find me the number, ere again you come,
Whose square when lessened by its seventh sum
Is then worth naught." Now hasten to the task,
And make all speed to find me what I ask.

(*Letters march and form a figure eight, kneeling on the grass.*)

'Tis wrong, what you suggest.
"8" will not end our quest.

(*They try again, this time forming a four.*)

That's not the one I need,
But one more trial—Proceed.

(*Letters form a ten.*)

Nay, nay, that will not do. It is not right.
'Tis not the number that the Queen desires.

Digitized by Google

But thou, fair X, art wiser than the rest—
I beg you stay.
The rest away.
I have no further need of you today.

(*Alphabet exeunt, all but X.*)

Now, X, bring aid.
On you is laid
The task the Queen did ask of me.
"Find me the number—seek it with great care—
Whose seventh sum, while it makes less the square,
Doth equal naught." This, the Decree.

(*While she speaks, the ten other X's enter. They come quickly up to X, and she joins herself to them.*)

These ten strange X's joined to mine, I see
Have made the sum of X's eleven, for me.

(*Enter three $-X$'s. They are joined by three of the girls, and wander off together.*)

These minus X's through an adverse fate
Have changed the total number back to eight.
Alas, 'tis ever thus with girls in Math.
My problems and my theory they forsake
When men are near. 'Tis many an hour they waste
In talking, roaming care free through the wood.
As to the rest, my faithful eight, to you
I give the task: to find the answer true.

(*Enter the Number System.*)

Welcome, O Number System, to our land.
Whence come ye, and what seek ye at our hand?

Zero— We come from far, in search of lady fair,
One X, whose name is honored in the realm
Of Math, wherever Algebra is known.
Under her rule, her subjects, would we be.

Algebra—Yonder she stands, my friend and helper, she.

(*Number System leads X to one side, 2 puts his crown on her, they help her onto a log, and all hail her as queen.*)

Algebra—Look now, what do I see? X raised to power.
The Numbers crown her, seek her for their Queen
And place upon her head their crown of two,
The index of her power. By a log
They've raised her thus above the other X's.
She's now the square of what before she was.
The square—the SQUARE—why now I see—

Digitized by Google

She is the first part of the Queen's decree.
And for the rest, the sum of *X*'s left
Is seven. If this be naught, my *X* is the one
Whose square when lessened by its seventh sum
Is then worth naught.

Zero— I am but naught; if any help I'd be
In your great search, I'm ready for the task
And I'll be equal to whate'er you ask.

Algebra—Come all, according to the Queen's decree
Let me find out what number *X* may be.

(*They form the equation:* $x^2-7x=0$ *with X first, then the seven X's in a row and last Zero, holding the minus and equality signs in their proper places.*)

Algebra—*X* square minus seven *x* is naught. Yes, true.
When this is solved, my task indeed is through.

(*She waves her wand. In the confusion following, X is uncrowned. She takes 0 and 7 by the hand and brings them to Algebra.*)

Algebra—My problem solved. Two answers do you bring—
Seven and Naught. Yes, I receive them both:
For both fulfill the Queen's desire of one
Whose square, when lessened by its seventh sum
Is then worth naught.
Rejoice with me, my task is now complete.
In joy and honor to the court we'll go,
And there these wise solutions proudly will we show.
Come one, come all,
Away, away,
To the court of our Queen,
Our fair Queen of May.

A PROJECT IN ELECTRICITY FOR HIGH SCHOOL PHYSICS.

By Hiram W. Edwards,
University of California, Berkeley.

The following article is written for the purpose of suggesting to teachers of science classes a project which is centered about the construction of a multi-range voltammeter.

The object of the project is twofold. For the student, it presents a problem that challenges his ability to solve, establishes satisfaction in the making of a thing that is useful, instills an appreciation of good instruments and fosters the training of skill with the hands. For the school, it supplies a much needed piece of apparatus at a very small cost.

Digitized by Google

Several of these instruments have been made by students in classes under the supervision of the writer, which have ranges of 0-15. and 0-1.5 volts and amperes. The finished product has been found to be serviceable as a sensitive galvanometer in such work as measurement of resistance by the wheatstone bridge. The cost has varied from fifty cents to a little more than a dollar.

The nucleus of the instrument consists of a moving coil type of ammeter such as is found in many automobiles. These have been obtained from dealers in the parts of wrecked automobiles. The price varies somewhat with the ability of the buyer but should be purchased for not more than one dollar. As a rule nothing more than slightly worn pivots will be found requiring adjustment.

Other materials needed will be a few inches of copper wire, from 200 to 1250 ohms of No. 36 german silver wire, and a few binding posts. A small board will be found convenient upon which to mount the instrument, its coils and shunts.

The method of construction is essentially as follows:

1. An inspection of the instrument will have to be made to insure freedom of the moving parts. Defective connections should be remedied. On account of the wear on the ends of the pivot, the screws holding the jewelled bearings should be turned in a little.

2. The old shunt will have to be removed. This is usually soldered to the screw binding posts and is easily taken off.

3. The instrument should be mounted on a small board with its face in a vertical position. Mounted in this manner it is easy to place shunts on the binding posts or to connect the resistance coils of the voltmeter to one of the posts. Without shunts or coils the instrument is ready to be used as a detector of small currents by connecting the binding posts directly to the circuit. When used as a galvanometer care must be taken not to let any but small currents pass through it, or the springs will be destroyed.

4. To extend the range of the instrument as a voltmeter, it will be found convenient to have two coils made from high resistance wire. On account of the large number of different types of ammeters which may be used for this purpose it is impossible to say how much resistance will be required for each coil. The resistance needed should be determined by trial so that when one of the coils is connected in series with the instrument one volt will give a deflection of one scale division. The

Digitized by Google

other coil may be adjusted to give a deflection of ten scale divisions for one volt. If a reliable voltmeter is not available for calibration by comparison, then a Daniell cell, which gives a pressure of 1.1 volts, will be found convenient. When the adjustment is completed it is best to mount the coils on appropriate spools provided with binding posts so that proper connection to the instrument may be quickly made.

5. The shunts for the ammeter may be made from short pieces of copper wire. The exact length of one will have to be determined by trial so that when one ampere is passing through the circuit that a deflection of one scale division is produced. The length of the other shunt should be such that one ampere will give a deflection of ten scale divisions The ends of the wires serving as shunts should be soldered to copper or brass washers which have had slots cut from one side to permit easy placement on the binding posts. The washers should be securely clamped on the binding posts between two nuts, one of which should be soldered to the binding posts. After completion each shunt should again be carefully tested for accuracy. Care must be taken to prevent any large current from passing through the moving coil of the instrument when a shunt is not in place.

The completion of an instrument such as is described briefly above will ordinarily take about three hours. The writer considers the results achieved well worth the time required.

BITUMINOUS COAL INDUSTRY.

At the February meeting of the American Institure of Mining and Metallurgical Engineers in New York the afternoon session on Tuesday, February 17, was devoted to a discussion of the bituminous-coal industry. The fluctuations in production and their extent and causes were discussed in a paper by George Otis Smith, Director of the United States Geological Survey, Department of the Interior, and F. G. Tryon, the coal statistician of the Survey. The statistical facts collected by the Survey during the last 30 years were graphically set forth in a dozen diagrams and certain broad conclusions were drawn from these facts.

The "bad load factor" of the soft coal mines of the country shows itself in the annual, seasonal, and daily fluctuations in coal production. On the average, during the past 30 years the mines have been idle 93 working days in the year.

The national interest in bettering the load factor of the soft-coal industry is measured by the fact that we have an excess mine capacity of at least 150 million tons and an excess labor force of perhaps 150,000 men. In terms of man-days, universal military training of our young men for three months would cost the nation less than the present enforced idleness in coal mining.

Digitized by Google

THE THEOREM OF NICOMACHUS.

By Oscar Schmiedel,

Parsons College, Fairfield, Iowa.

The article on "Useful Benefits from Study of Mathematical History," on page 463 of the May number of this journal, has been made the subject of criticism on page 663 of the October number. The aim of the criticism, if I understand aright, is to show that the theorem in the May number, which says, that any power of an integer is expressible as a sum of consecutive odd numbers, is a mere special case of the more general principle, that the product of two integers is similarly expressible.

A few minor points, where the meaning is not clear, should be noticed first. We ask: Should we not be grateful for any facts preserved for us in history which, though trivial in themselves, may throw a light upon the intellectual attainments of those distant ages? And are not often such facts thought trivial merely because they stand dissociated from the causes that gave rise to them, and because they have been disregarded by later writers, and are they not therefore often of the kind of uncompleted problems mentioned? Why "charity" for Nicomachus? The Pythagorean philosophy made number the essence of all things[1]; the universe, as one vast harmony, itself was number, and virtues resided in numbers. Nicomachus, who first compiled arithmetical knowledge into a system, and wrote the Elements of Greek arithmetic, was a Pythagorean, who believed in the doctrines of the school and labored to perpetuate them. He does not hesitate confessing pleasure in facts of his own discovery, though trite and void of any importance as seen in the light of present-day knowledge, as when he found the difference between the heteromecic and square numbers to be the natural numbers: $2-1, 6-4, 12-9, \ldots$ respectively, $1, 2, 3, \ldots$. Is it hard to conceive that he should pride himself upon his discovery of a new relation between numbers similar to that important one due to the Master; and should deem it important, too? However, he is innocent of the charge; and yet, he certainly must have thought his theorem of sufficient importance to have it transmitted, and history transmitted it. History speaks of it as "pretty"[2]; as "extraordinarily interesting"[4] on account of its application to the summation of the cubes of numbers; as an "important proposition."[5]

The importance of a thing is relative. What yesterday shone bright with promise, may today sink into insignificance, and tomorrow, when the constellations change, resume its former lustre. Importance may inhere in directive propensity.

That the enlarged theorem which extends the forms given by Pythagoras and Nicomachus to any powers of integers should be a half-truth only is not certain. On the contrary, the theorem appears complete and independent in itself. Nor can it be admitted that the terms of the development must necessarily be found by considering the average of the sum of terms, which procedure, it is said, would obviate elaborate calculation. The terms are found quite in the manner indicated in the article itself. Manifestly, 16 is the fourth part of the product $4 \cdot 16$, and hence of the sum equivalent to that product, i. e., the average of the sum of all the terms. But how, without further calculation, the terms themselves are found from this average is not revealed. How is the first term to be

[1] *Biographie Universelle*, vol. 34, Pythagore.
[2] M. Cantor, *Geschichte der Mathematik*, I, 429.
[3] G. H. F. Nesselmann, *Die Algebra der Griechen*, page 210.
[4] Cantor, page 432.
[5] F. Cajori, *History of Mathematics*, Ed., 1917, page 32.

Digitized by Google

found for the product 4·1? How for 4·25? The rule stated might answer when the sum is given and the product to be found; but to cover this entire phase of the question well, it should be supplemented by some statement such as this: The first term of the sum is the difference of the factors increased by 1, the last their sum decreased by 1.

Will the writer of the criticism be consistent and call his own principle a half-truth if it should appear that it, too, is but a part of a more comprehensive one? It has already been suggested where his statement is deficient. Would b in the product $4 \cdot 25 = -1\frac{1}{4} - \frac{1}{4} + \frac{5}{4} + 1\frac{1}{4}$ be odd or even? His principle, in order to include this case, might suitably be generalized and stated thus: The product of two numbers, one of which, a, is an integer, the other, b, any number whatsoever, may be written as a sum of terms with a common difference, 2, e. g., $4 \cdot 1 = -2+0+2+4$; or, as a formula:

$$ab = (b-a+1) + (b-a+3) + \ldots + (b+a-1), \qquad (1)$$

from which the rule for the first term may be abstracted as above. But must the difference be 2?

It may be noticed in this sum that b occurs in every term and, there being a such terms, the b's alone will give the product, ab; hence the aggregate of all the quantities combined with b must vanish. This suggests that the a terms of the sum may be composed in any manner whatsoever, only so that b appears as term in each, and the sum of all the other quantities is zero. Thus, the square of 5 may be expressed as a sum of five successive integers:

$$5^2 = (5+5+5+5+5) + (-2-1+0+1+2)$$
$$= 3+4+5+6+7.$$

The simplest case for a common difference among the terms occurs where the difference is 1, and the development as a formula will be:

$$ab = [b+\tfrac{1}{2}(1-a)] + [b+\tfrac{1}{2}(3-a)] + \ldots + [b+\tfrac{1}{2}(a-1)]. \qquad (2)$$

In general, for a common difference, r:

$$ab = [b+\tfrac{r}{2}(1-a)] + [b+\tfrac{r}{2}(3-a)] + \ldots + [b+\tfrac{r}{2}(a-1)]; \qquad (3)$$

where r may be any integer, including 0. Of all the values r may have, only one, namely 2, is needed to give the form set forth.

But more: This difference, so far taken constant, may change from term to term, and yet produce a sequence of which (1) is a special case. Thus, $4 \cdot 5 = 4+6+5+5 = -7-1+8+20 = -23-14+10+50$, etc., all lawful sequences the general term of which is:

$$ab = [b-(a+n)^n + (n+1)n^n] + [b-(a+n)^n + (n+1)(n+1)^n] + \ldots$$
$$+ [b-(a+n)^n + (n+1)(n+a-1)^n], \qquad (4)$$

where m^n stands for the binomial coefficient defined as:

$$m^n = \frac{m(m-1)\ldots(m+n-1)}{1 \cdot 2 \ldots n}$$

If in (4) the quantities following b in each term be multiplied by r, the resulting form will be more general yet. By taking r and n each equal 1, the form will again result from it as special case.

All that has been said so far refers to products with two factors only. Now the product $abcd \ldots$ to n factors might be developed; then taking $n = 2$, that same principle will appear a special case also of this. And so on in endless variety.

Once more: The assertion is made that Nicomachus' theorem has no foundation as a mathematical principle. If his be true, then, whatever be the meaning of the declaration, it would equally apply to the extended theorem given in the form:

$$a^n = (a^{n-1} - a+1) + (a^{n-1} - a+3) + \ldots + (a^{n-1}+a-1)^6. \qquad (5)$$

Should it now prove possible to derive (1) from (5), would the principle be held to be without foundation as a mathematical principle?

Digitized by Google

But this can be done, since (5) is a function of two parameters, a and n, and therefore expressible in terms of other two parameters, as a and b. Assuming $b = a^{n-1}$, and making the substitution, at once leads back to (1); and the case is proven.

For illustration let $a = 4$, $b = 2/3$; and n in (5) will be $= \frac{1}{2}(3 - \log 3/\log 2)$, or .75 approximately. Development by (1) gives:

$$4.2/3 = -7/3 - 1/3 + 5/3 + 11/3.$$

Now granting all this as true and to the point, the statements in the May number retain their validity and still represent what it had been intended they should represent: an effort to illustrate the value of historic study by the generalization of the theorems of Pythagoras and Nicomachus in the sense and form of their discoverers.

Entirely similar criticisms might have been advanced on the formula at the bottom of page 463, which is:

$$a^n = (a^{n-m} + a^m/2)^2 - (a^{n-m} - a^m/2)^2; \qquad (6)$$

for Euclid has the identity

$$ab = (a + b/2)^2 - (a - b/2)^2,[7] \qquad (7)$$

from which (6) may be derived.

On the other hand, (7) may be derived from (6) by assuming $b = a^{n-1}$ and $m = 1$. Other values of m will give relations not directly found in Euclid's form. Hence (6) appears the more general of the two. Thus, to develop 5^2, let m in (6) be 2, and the result is: $5^2 = 13^2 - 12^2$; while (7) gives only the palpable identity $5^2 = 5^2$.

By proper choice of n and m, (6) will yield the identity:

$$a^n = (a^n + 1/2)^2 - (a^n - 1/2)^2, \qquad (8)$$

giving the nth power of a number in terms of squares of numbers which differ by unity and the sum of which is that same power; as, $5^3 = 63^2 - 62^2$; or the identity:

$$4a^2 = (a^2 + 1)^2 - (a^2 - 1)^2, \qquad (9)$$

which is Plato's form for integral values of the sides of right triangles; or many more.

History does not relate how Pythagoras came to discover the relation between the sides of the right triangle. But having knowledge of the theorem that the sum of consecutive odd numbers is the square of a number; and having deduced from it the relation of numbers expressed in a general way by (6), from which sets of integers could be computed such that the sum of the squares of two of them would give the square of a third; and considering the fact already familiar that one of these sets, 3, 4, 5, may represent the sides of a right triangle, it is easy to conceive how he should have been led to experiment with other sets for the same purpose; and finding his surmise confirmed, after many trials more perhaps, succeed to a rigorous geometrical proof of that theorem of unquestioned importance according to which the sum of the squares of the sides of a right triangle is always equal to the square of the hypothenuse.

This "the student of history is compelled . . . to believe" was the course[8] by which that fundamental theorem came to light; and thus the common observation is confirmed that simple truths, themselves of not too great utility, may play a role of great importance in new discoveries.

It is known that Sir Isaac Newton felt his way to the binomial theorem by experimenting with such trivial things as the sets of numbers: 1, 1; 1, 2, 1; 1, 3, 3, 1; etc., with the expressed design of ascertaining if a universal law could be established that would uniformly give these numbers one from the other in succession; and that he thus intuitively arrived at

[6] *Cantor, Geschichte, Vol. I.* page 432, footnote 2.
[7] *Elements*, Bk. X, Th. 29, Lem. I.
[8] Tropke, *Geschichte der Elementar-Mathematik, Vol. II*, page 71.

Digitized by Google

the general form $n/1\cdot(n-1)/2\cdot(n-2)/3\cdot\ :\ \cdot\ \cdot$, and thence the binomial theorem.

It is this process of inductive reasoning, this procedure from special cases to general laws, the article in the May number meant to emphasize and set it forth as under contribution to the study of history.

PROBLEM DEPARTMENT.

Conducted by J. A. Nyberg.

Hyde Park High School, Chicago.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. If you have any suggestion to make, mail it to him. Address all communications to J. A. Nyberg, 1044 E. Marquette Road, Chicago.

SOLUTION OF PROBLEMS.

631. *A solution by Katherine S. Arnold, Milwaukee-Downer College, was received too late for publication.*

639. *A solution by Hazel C. Jones, Danville, Ill., was received too late.*

641. *Proposed by Walter R. Warne, State College, Pa.*

Eliminate x between the equations

$$x+1/x = y$$
$$x^5+1/x^5 = z.$$

Solution by N. Anning, Orono, Me.

$$\begin{aligned} y^5-z = (x+1/x)^5-x^5-1/x^5 &= 5[(x^3+1/x^3)+2(x+1/x)] \\ &= 5y(x^2-1+1/x^2+2) \\ &= 5y(y^2-1) \\ &= 5y^3-5y. \end{aligned}$$

Eliminant: $z = y^5-5y^3+5y$.

Note: If $y = 2\cos\theta$, $z = 2\cos 5\theta$.

Also solved by Henry Ruzicki, St. Martins College, Lacey, Wash.; H. C. Whitaker, Philadelphia; C. E. Githens, Wheeling, W. Va.; Ethel Snider, Piermont, N. Y.; A. Pelletier, Montreal, Can.; irrational forms of the eliminant were found by Walter R. Warne, by Thomas E. N. Eaton, Redlands, Calif., and by R. T. McGregor, Elk Grove, Calif.

642. *Proposed by Abigail Glenn, Student, Chicago Normal College.*

What value of b will make b^4+30b^2+25 a perfect square?

I. *Solution by A. Pelletier, Montreal, Can.*

Let $b^4+30b^2+25 = (b^2+x)^2$

Then $b^2 = (x^2-25)/(30-2x)$

There being no restriction as to the nature of the values of b, we may give to x any value, and then determine b.

Also solved similarly by Herbert C. Whitaker, Philadelphia.

II. *Solution by Walter R. Warne.*

Assume $b^4+30b^2+25 = (pb^2+5)^2$, p arbitrary.

Then $b^2 = 10(p-3)/(1-p^2)$. When $p = \pm 1$, the formula fails.

Digitized by Google

Also solved by N. Anning. The trivial solution $b = 0$ was sent in by three contributors. and the special values $b = 2\sqrt{3}$, 6 by another. A second solution by N. Anning is very interesting:

III. Comparing b^4+30b^2+25 with the left-hand side of the algebraic identity,

$(2xy+6y^2)^2+6(2xy+6y^2)(x^2-y^2)+(x^2-y^2)^2 = (x^2+6xy+y^2)^2$,

we see that the given expression is a perfect square if

$$b^2 = 2y(x+3y),$$
$$5 = x^2-y^2.$$

Let $x+y = 5k$, where k is any rational number except 0, and $x-y = 1/k$,

$$x = (5k^2+1)/2k, \quad y = (5k^2-1)/2k,$$
$$b^2 = 2y(x+3y),$$
$$= (5k^2-1)(10k^2-1)/k^2.$$

And, putting k^2 = the positive rational number, p,

$$b^2 = 50p-15+1/p.$$

Check: When $p = 1$, $b^2 = 36$ and $b^4+36b^2+25 = 49^2$
When $p = 1/5$, $b^2 = 0$ and $b^4+36b^2+25 = 5^2$
When $b^2 = 50p-15+1/p$, then
$b^4+30b^2+25 = (50p-1/p)^2$.

643. *Proposed by Walter R. Warne, State College, Pa.*

The sum of three terms of an harmonic series is 11, and the sum of their squares is 49. Find the numbers.

Solution by Thos. G. Brown, Boys' Technical High School, Milwaukee.

Terms of series
a, b, c,
Then $b = 2ac/(a+c)$,
By hypothesis

$$a+2ac/(a+c)+c = 11 \text{ or } 2ac/(a+c) = 11-a-c \qquad (1)$$

and

$$a^2+[2ac/(a+c)]^2+c^2 = 49 \text{ or } [2ac/(a+c)]^2 = 49-a^2-c^2 \qquad (2)$$

Substituting (1) in (2) and simplifying

$$a^2+c^2+ac-11(a+c)+36 = 0 \qquad (3)$$

Clearing (1) of fractions and subtracting from (3)

$$-3ac+36 = 0$$

or

$$c = 12/a \qquad (4)$$

Substituting (4) in (1)

$$a^2+144/a^2+48-11(a+12/a) = 0,$$

Whence

$$(a+12/a)^2-11(a+12/a)+24 = 0,$$

Whence

$$a+12/a-8 = 0, \quad a+12/a-3 = 0.$$

Solving

$$a = 6, \ 2, \ (3+\sqrt{-39})/2, \ (3-\sqrt{-39})/2$$
$$b = 3, \ 3, \ 8, \ 8,$$
$$c = 2, \ 6, \ (3-\sqrt{-39})/2, \ (3+\sqrt{-39})/2,$$

Also solved by N. Anning, and A. Pelletier. Incomplete solutions in so far as the irrational values were omitted were sent in by Thomas E. N. Eaton, Ethel Snider, C. E. Githens, R. T. McGregor, Herbert C. Whittaker, Philadelphia, and Katherine S. Arnold. The Proposer also solved it ingenuously by using the relation $a/c = (a-b)/(b-c)$.

644. *Proposed by H. C. Peterson, Chicago.*

Suppose a rectangular strip of paper with vertices A, B, C, D, consecutively (AB representing the length). Fold on some line, say EF (E on AB, F on CD) so that EA will intersect FC in point G, say, making EFG an equilateral triangle.

Solution by A. Pelletier, Montreal, Can.

We have simply to draw EF so that $\angle AEF = 60°$. In order to have

Digitized by Google

an intersection G, we must have $AE \geq 2AD/\sqrt{3}$ and $EB \geq AD/\sqrt{3}$. Hence, there is no solution when $AB < AD\sqrt{3}$, one solution for $AB = AD\sqrt{3}$, and an infinite number for $AB > AD\sqrt{3}$.

Also solved by Ethel Snider.

645. *Proposed by Walter R. Warne.*

If $abcs = 8\Delta^2$, where a, b, c represent the sides of a triangle, s the semiperimeter and Δ the area, prove the triangle is equilateral.

I. *Solution by Norman Anning, Orono, Maine.*

$$abcs = 8\Delta^2$$
$$= 8s(s-a)(s-b)(s-c).$$
$$abc = (b+c-a)(c+a-b)(a+b-c).$$

Expanding and recombining,

$$a^2+b^2+c^2-b^2c-bc^2-c^2a-a^2c-a^2b-ab^2+3abc = 0$$
$$(s-a)(b-c)^2+(s-b)(c-a)^2+(s-c)(a-b)^2 = 0.$$

Now, since a, b, c are the sides of a triangle, $s-a$, $s-b$ and $s-c$ are positive and $(b-c)^2$ etc., cannot be negative. Consequently,

$$b-c = c-a = a-b = 0$$

and the triangle is equilateral.

Also solved by A. Pelletier. C. E. Githens proved the converse of the problem.

II. *Comment by Herbert C. Whitaker, Philadelphia.*

The following relations between the parts of any triangle are well known,

$$4\Delta R = abc$$
$$\Delta = rs$$

Multiply these and the given equation

$$R = 2r.$$

Now it is necessary in an equilateral triangle that the radius of the circumscribed circle should be twice the radius of the inscribed circle, but I do not think that the relation $R = 2r$ is sufficient to establish that the triangle is equilateral.

PROBLEMS FOR SOLUTION.

656. *Proposed by F. A. Cadwell, St. Paul, Minn.*

ABC is an isosceles triangle, AB = AC; and AE is a line not cutting the sides of the triangle. A point D on AE is chosen so that BD = BC and $\angle ADB = 150°$. Prove $\angle DAB$ is one-third of $\angle DAC$.

657. *Proposed by Walter R. Warne.*

If $x^2 = a^2+b^2$, $y^2 = c^2+d^2$, show that $xy > (ac+bd)$.

658. *Proposed by J. A. Nyberg, Hyde Park High School, Chicago.*

Given two points A and B. Find, using only dividers, two points C and D, so that ABCD (in order) will be the corners of a square.

659. *Suggested by H. C. Whitaker's comment on problem* 645.

Prove geometrically that if $R = 2r$, the triangle is equilateral.

660. *Proposed by Martha G. Lathrop, Emmett, Idaho.*

Given three unequal non-intersecting circles O, O,′ O″. Let A be the intersection point of the common external tangents of O and O′, B the point for O′ and O″, C the point for O″ and O. Prove A, B, and C are collinear.

Springfield, Mass., March 23, 1920.

Mr. W. H. Maddock, who has long been our representative in the educational field, will, after April 1, have charge of our Educational department, and make his home in Springfield.

In this broader field we bespeak for him a continuance of the kindly consideration that has always been extended to him and to us in the past.

G. & C. MERRIAM COMPANY.

Digitized by Google

ARTICLES IN CURRENT PERIODICALS.

American Bot nist, for February; *Joliet, Ill.; $1.50 per year, 40 cents a c·py:* "Plant Names and their Meanings," Willard N. Clate; "Wildflower Distribution in the West," Blanche H. Soth.

Am·rican Journal of Botany, for February; *Brooklyn Botanic Garden, Bro klyn, N. Y.; $6.00 per year, 70 cent· a copy:* "Effect on Chestnuts of Substances Injected into Their Trunks," Caroline Rumbold; "Subalpine Lake-Shore Vegetation in North-Central Colorado," Francis Ramaley; "Some Observations on the Spore Discharge of Pleurage Curvicolla (*Wint.*) Kuntze," J. L. Weimer; "Correlation Between Size of the Fruit and the Resistance of the Toma·o Skin to Puncture and Its R lation to Infection with Macrosporium Tomato Cooke," J. Rosenbaum and Charles E. Sando.

American Math·matical Monthly, for March; *Lancaster, Pa.; $3.00 per year, 35 cents a copy:* "Fourth Annual Meeting of the Mathematical Association of America," Professor W. D. Cairns; "The November Meeting of the Illinois Section," Dr. E. B. Lytle; "Questions and Discussions," "Recent Publications," "Problems and Solutions."

Condor, for January-February; *Berkeley, California; $2.00 per year, 40 ents a copy:* "Autobiographical Notes" continued), Henry W. Henshaw; "Importance of the Blind in Bird Photography" (with six photos), Frank N. Irving; "The Rusty Song Sparrow in Berkeley, and the Return of Winter Birds," Amelia S. Allen; "A Peculiar Feeding Habit of Grebes," Alexander Wetmore; "A Return to the Dakota Lake Region" (contin·ued , Florenc M. Bailey; "Notes on the Limico ae of Southern British Columbia," Allan Bro ks.

Journal of Geography, for February; *Broadway at 156th Street, New York; $1.00 per y ar, 15 cen·s a copy:* "Suggestions for a Study of Latin America Based Upon Our Trade Relations," E. Curt Wal her; "Problem Teaching: How to Plan for It," Ruby Minor; "The National Council of Geogra, hy Teachers," George J. Miller.

L·terary D gest, for March 13; *354 Fourth Ave., New York City; 10 cents a copy:* "Labor's Verd ct on Proh bition"; "What to Hope from the Railroads"; "The Steel Trust Finds it Pays to Be Good"; "Our S·ake in the Adriatic"; "Lenine's Puzzling Peace Offer"; "Labor Awakening in Japan"; "Ca· ada's Voice in the League."

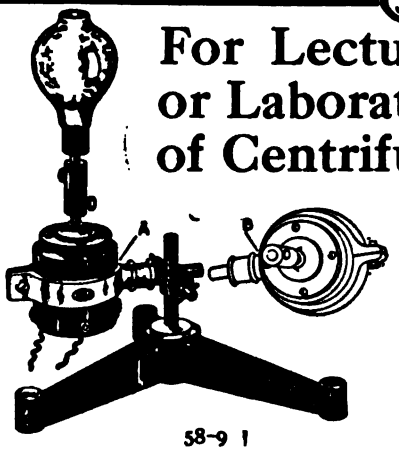
National Geographic Magazine, for March; *Washington, D. C.:* "Massachusetts—Beehive of Business" (41 illustrations), William J. Showalter; "Fo.mosa the Beautiful" (60 illustra ions), Alice B. Ki jassoff.

Nature Study Review, for Feb uary; *Ithaca, New York; $1.00 per year, 15 cents a copy:* "A Neglected Side of Nature Study," S. C. Schumaker; "Th· Relation of Nature Study to Boys and Girls Club Work," Theodosia Hadley; "Additional Science Tests in the Grades," E. R. Dow ing; "The Co nell Rural School Leaflet and Conservation," E. L. Palmer; "Geography and Life," A. B. Comsto·k.

Photo-Era, for March; *Boston, Mass.; $2.00 per year, 20 ents a copy:* "How to Know Your Best Photographs," Winn W. Davidson; "Odd French Co ners for the Camerist," Herbert B. Turner; "Home-Portraiture —Dealing with Sunshine," Wilson Todd; "Save It!" Frede·ick C. Davis; "Some Critics on 'Li·keness' in Portraits," The British Journal; "An Actor and His Hobby," Hamilton Revelle; "How I make My Bromoil-Prints," G. Bellamy Clifton.

Physical Review, for February; *Ithaca, New Yor·; $7.00 per year, 75 ents a copy:* "The Nuclei of Atoms and the New Periodic System," W. D. Harkins; "The Bohr Theory and the Approximate Harmonics in the Infra-Red Spectra of Diatomic Gases," Edwin C. Kemble; "Reflection and Transmission f Ultra-Violet Li·ht by Sodium and Potassium," Mabel K. Frehafe·.

Digitized by Google



58-9 I

The Waverley-Electric Specifications

Support—Standard Tripod.
Yoke—Cast Aluminum.
Housing—Enameled Iron.
Motor—6,000 R. P. M.
Mica Insulation. Self-Adjusting Brushes.
Ball-Bearing Shaft.
Current—D. C., A. C., or Dry Cells.
Chuck—Universal.

For Lecture Demonstration, or Laboratory Application, of Centrifugal Force . . . . .

You Need This Waverley Electric—
A Whirling Machine and Centrifuge Combined.

As a whirling machine the Waverley-Electric takes a Centrifugal Globe (as illustrated), or Double Hoops, Centrifugal Balls, and other accessories.

A Centrifuge Head converts the Waverley-Electric into a powerful centrifuge that may be used with efficacy for the analysis of milk, urine, blood, or other liquids.

The specially designed, ball-bearing motor is mounted and balanced to operate in vertical or horizontal position. Consequently its general utility includes the rotation of Savart's Wheels, Siren Discs, Newton's Color Discs and the like.

58-9 **The Waverley-Electric, including Support, Yoke, Motor and Chuck.....$19.00**
58-9a **Waverley Centrifuge Head, four-arm.. 3.75**

Cambridge Botanical Supply Company

LABORATORY EQUIPMENT—ALL SCIENCES

1-9 Lexington Street **1884-1920** **Waverley, Mass.**

EDUCATION

40th year Sept. 1919. $3 a year. Sample 20c.
120 Boylston St., Boston, Mass.

"AS NECESSARY TO A TEACHER AS A MEDICAL JOURNAL TO A PHYSICIAN"

Popular Astronomy, for March; *Northfield, Minn.; $4.00 per year:* "Occultation of Satellite I by Satellite III, in the Jovian System" (with Plate VIII), George H. Hamilton; "First Study of Heavenly Bodies," Lesson III, Mary E. Byrd "On the Solar Radiation," Jason J. Nassau; "The Use of Selenium Cells in Astronomy," Lewis J. Boss; "Astronomy in the High School," Ruby B. Albert; "A New Theory of the Deluge," H. P. Lee; "Astronomy in Daily Life," Gilbert P. Chase.

School Review, for March; *University of Chicago Press; $1.50 per year, 20 cents a copy:* "The Washington Junior High School, Rochester, New York," R. L. Lyman; "The Individual Pupil as the Unit of Supervision in High Schools" Morton Snyder; "Junior High-School Study Tests," Charles E. Finch.

Scientific Monthly, for March; *Garrison, New York; $5.00 per year, 50 cent a copy:* "Space, Time and Gravitation," Edwin B. Wilson; "The Need for a More Serious Effort to Resume a Few Fragments of Vanishing Nature," Dr. Francis B. Sumner; "The Origins of Civilization," James H. Breasted; "The Mechanism of Evolution," Edwin G. Conklin; "A Graphic Method of Measuring Civilization and Some of its Applications," Dr. Roland M. Harper; "Finis Coronat Opus," Frank V. Morley; "On Rhythm," D. Fraser Harris; for April: "The Beginnings of Human History Read from the Geological Record—The Emergence of Man," John C. Merriam; "The Measure of Excellence in Scientific Activity," R. D. Carmichael; "The Relation of Philosophy and the Sciences," G. R. Wells; "Why Does Our Public Fail to Support Research?" T. D. A. Cockerell; "Science and the State," Dr. William Salant; "Inertia," Sir Oliver J. Lodge; "The Mechanism of Evolution," Professor Edwin Grant Conklin; "A Nature Drama," H. L. Fairchild.

Digitized by Google

BOOKS RECEIVED.

Infinitesimal Calculus, by F. S. Carey, University of Liverpool. Pages x+352+ix, 14×22 cm. Cloth, 1919. $4.25. Longmans, Green & Company, New York.

Plane Trigonometry for Secondary Schools, by Charles Davison King, Edard's High School, Birmingham. 334 pages. 13×19.5 cm. Cloth, 1919. The University Press, Cambridge, Eng.

Modern Junior Mathematics, Books I and II, by Marie Gugle, Assistant Supt. of Schools, Columbus, Ohio. Pages ix+222; xiv+239. 13.5×19 cm. Cloth. 1920. The Gregg Publishing Company, New York.

Second Course in Algebra, by Walter B. Ford, University of Michigan, and Charles Answerman, McKinley High School, St. Louis. Pages ix+299. 13×19 cm. Cloth. 1920. $1.28. The Macmillan Company, New York.

Word Study for High Schools, by Norma L. Swan, Long Branch High School. Pages xi+142. 13.5×19. Cloth. 1920. 72 cents. The Macmillan Company, New York.

Problems in Botany, by W. L. Eikenbery, University of Kansas. Pages xii+145. 14.5×21 cm. Cloth. 1920. 72 cents. Ginn and Company, Chicago.

Proceedings of the High School Conference, 1919, University of Illinois, by the High School Visitor. 313 pages. 15×22.5 cm. Paper. 1920. The University of Illinois Press, Urbana.

Physiology and Hygiene by Charles P. Emerson, University of Indiana, and George H. Belts, Northwestern University. Books I and II. Pages 188 and 323. 14.5×19. Cloth. 1919. Bobbs-Merrill Company, Indianapolis.

Physics, by Willis E. Tower, Englewood High School, Chicago, Charles H. Smith, Hyde Park High School, Chicago, Charles M. Turton, Bowen High School, Chicago, and Thomas D. Cope, University of Pennsylvania. Pages xv+492. 14×20 cm. Cloth. 1920. $1.35. P. Blakiston's Son and Company, Philadelphia.

South, by Sir Ernest Shackleton; a story of his last expedition, 1914-17. Eighty-eight illustrations and diagrams. Pages xxi+374. 15.5×23 cm. Cloth. 1920. $7.00. The Macmillan Company, New York City.

Pamphlets Received.

Bulletin No. 50, The Public School System of Memphis, Tenn. Parts 2, 3, 5, 6 and 7, Department of the Interior, Bureau of Education, Washington, D. C.

Bulletin No. 76, Community Americanization, by Fred C. Butler, Department of the Interior, Bureau of Education, Washington, D. C.

Bulletin No. 52, Industrial Schools for Delinquents, by H. R. Bonner.

Bulletin No. 69, Proceedings of the Fourth Annual Meeting of the National Council of Primary Education.

Bulletin No. 54, The Schools of Austria-Hungary by Peter H. Pearson.

Bulletin No. 58, Commercial Education by Glen L. Swiggett.

Bulletin No. 66, Training Teachers of Agriculture.

Bulletin No. 4, The Problems of Adult Education in Passaic, New Jersey.

The Work of the American Red Cross During the War, a Statement of Finances and Accomplishments for the Period, July 1, 1917, to February 28, 1919.

Journal of the Mathematical Association of Japan for Secondary Education.

Cornell University, The President's Report for 1918-1919.

Digitized by Google

Mathematics and Modern Life

To relate them in the mind of the junior high school pupil is no mean achievement. But it is necessary, and the Wentworth-Smith-Brown Books I, II and III have done it with phenomenal success. Moreover, these books are so varied and interesting in the problems they present that they are thoroughly *teachable.*

WENTWORTH, SMITH AND BROWN'S

Junior High School Mathematics

GINN AND COMPANY

Boston New York Chicago London
Atlanta Dallas Columbus San Francisco

THE AMERICAN MATHEMATICAL MONTHLY

OFFICIAL JOURNAL OF

The Mathematical Association of America

Is the Only Journal of Collegiate Grade in the Mathematical Field in This Country

This means that its mathematical contributions can be read and understood by those who have not specialized in mathematics beyond the Calculus.

The Historical Papers, which are numerous and of high grade, are based upon original research.

The Questions and Discussions, which are timely and interesting, cover a wide variety of topics.

Surveys of the contents of recent books and periodicals constitute a valuable guide to current mathematical literature.

The "Topics for Undergraduate Mathematical Clubs" have excited wide interest both in this country and in Great Britain.

The Notes and News cover a wide range of interest and information, both in this country and in foreign countries.

The Problems and Solutions hold the attention and activity of a large number of persons who are lovers of mathematics for its own sake.

There are other journals suited to the Secondary field, and there are still others of technical scientific character in the University field; but the monthly is the only journal of Collegiate grade in America suited to the needs of the non-specialist in mathematics.

Send for circular showing the articles published in the last six volumes.

Sample copy and all information may be obtained from the

SECRETARY OF THE ASSOCIATION

27 King Street OBERLIN, OHIO

Please mention School Science and Mathematics when answering Advertisements.

Digitized by Google

PHYSICS TEST.

By C. P. FINGER
Ferndale. Calif., Union High School.

Complete broken sentences, and answer questions with one word if possible.

Mechanics.

The inertia of a body is measured by its ..... The resistance a body offers to being torn apart is ..... The unit of capacity in the Metric System is the ..... It is equal to..... smaller units known as..... One meter equals ..... inches and one kilogram is equal to ..... pounds. For tubes of small diameter, the elevation or depression of a liquid in them is ..... proportional to ..... Pascal's principle states that the pressure applied to an enclosed fluid is transmitted ..... to every part of ..... In a liquid the downward pressure is ..... proportional to ..... and is independent of ..... Archimede's principle is stated as follows: A body immersed in a fluid ..... The density of a heavy insoluble solid may be found by ..... and ..... and may be computed by dividing the ..... by the ..... Boyle's Law states that the ..... of a gas varies ..... The line described by a moving point is called its ..... Rectilinear motion is exemplified by .....; rotary motion by ..... and simple harmonic motion by ..... A formula showing the relation between speed and time in variable motion is as follows:..... ..... one showing relation between distance and time and acceleration in a freely falling body is ..... and one connecting up velocity distance and acceleration is..... The gravitational unit of force (metric) is the ..... The absolute unit is the ..... and ..... of the smaller units equals one ....., a larger unit. The resultant of two parallel forces in the same direction is ..... and its point of application divides the line joining the points of application of the two forces into part which are proportional to ..... Momentum is the product of ..... and .....; Impulse is the product of and .....; Force may be expressed as the product of ..... and ..... For a simple pendulum the period is ..... proportional to amplitude and ..... to the length and ..... to acceleration due to gravity. Work is measured by the product of ..... and .....; and an English unit of work is the ..... The absolute unit of work is the ..... and a larger unit is the ..... and is equal to ..... of the smaller units. Potential energy is due to ..... or a .....; Kinetic energy to ..... and the kinetic form may be represented by the formula: The mechanical advantage of a machine is the ratio of ..... to ..... or the ratio of ..... to the ..... For an inclined plane this may be stated as the ratio of ..... to ..... The efficiency of a machine is the ratio of..... to .....

BOOK REVIEWS.

Psychology from the Standpoint of a Behaviorist, by John B. Watson, Johns Hopkins University. Pages XIII×429. 15x21.5 cm. Cloth. 1920. J. B. Lippincott Co., Philadelphia, Pa.

This is a most remarkable book and is treated in a most thorough and understandable way by one who is thoroughly competent to write upon this subject. The text is compiled in such a manner that any properly trained individual may read and understand the matter presented. The

Digitized by Google

Blakiston

TOWER, SMITH, TURTON AND COPE

Physics

A textbook, besides imparting to the pupil the actual information sought, should inspire him to original effort and the consequent mastery of each problem. It should be a stimulus, a challenge and a guide to thinking about familiar physical phenomena with the aim to make the pupil study physics, not in the class-room alone, but on the street, in the car, and in his home. That is the aim of the present work.

With 455 Illustrations, Including 7 Plates. Cloth, $1.35 Postpaid.

* * *

AHRENS, HARLEY AND BURNS

Practical Physics Manual

While the study of physics of daily life is the keynote of the modern textbook, many of the laboratory manuals still adhere to the old method leaving the presentation of material from every-day life in the textbook alone. The present manual departs from the old method. Experiments are arranged for convenience in three distinct courses: general course; technical course; household physics course.

With 133 Illustrations. Cloth, $1.25 Postpaid.

* * *

NEUFELD

By J. L. NEUFELD, Central High School, Philadelphia

Elementary Algebra

With Table of Logarithms

"I couldn't understand the explanation in the book." How much of the teacher's and pupil's time is consumed and development of the class delayed by the necessity of reassigning work because the textbook fails to make the point clear? A new book which will correct this fault is now available. It is a work by an author of long experience. There are many special features of value which make the book of more than ordinary interest. An examination of this text will convince.

Illustrated. Ready in May.

P. BLAKISTON'S SON & CO.

PUBLISHERS **PHILADELPHIA**

Please mention School Science and Mathematics when answering Advertisements.

Digitized by Google

success of the teaching in the future is going to depend very largely upon those instructors who have a good foundation and knowledge of human psychology and without this knowledge teachers will be a failure. The one wishing to become familiar with the physiological psychology of the human being cannot do better than to secure a copy of this book and make a thorough study of it. Justice cannot be done to the book in a short review.

There are eleven chapters in the text. Major paragraphs begin with bold face type which presents the subject to be discussed in these paragraphs. There are sixty-five splendidly executed half-tones and drawings. It makes interesting reading for the intelligent layman and progressive teachers should possess themselves with a copy. C. H. S.

Every Step in Canning by Grace B. Carr, Iowa State College. Pages 253 13×19.5 cm, cloth, 1919. $1.25. Forbes Co., Chicago.

A most valuable and interesting book devoted to the canning and preserving of fruit, meats, and vegetables, with special application to the cold pack method. This book will fill a great demand as it is one that every housewife, who is at all prone to do preserving, will be interested in to the extent of purchasing a copy. Perhaps the cost of living in her particular family may be reduced by carrying out suggestions given in this book.

There are nineteen chapters which are carefully written and will prove a great help to the housewife. The book abounds in recipes and gives explicit directions as to the best method of preserving food for future use. A list of firms from which materials needed in the preservation of eatables may be secured. C. H. S.

Catalogue of Spencer Microscopes, Microtomes, and Accessories. Pages 116. 17×25 cm. Paper. 1920. Spencer Lens Co., Buffalo, N. Y.

One of the finest gotten up catalogues of this character that has ever come to our desk. It gives very minutely the apparatus and supplies handled by this most excellent firm. It abounds in half-tones of their microscopes and other instruments which are splendidly executed and printed on the highest grade of calendered paper. The book reflects the character of reliability of this firm. The sections of apparatus are clear and understandable. Telegraph code, catalogue number, and dimensions of the apparatus are given. The prices are not given in the body of the catalogue, due to the fact that in these times there is almost a continual changing; there are, however, supplements which give prices the same as February 10, 1920.

School officers, instructors, and others who are interested in microscopes and microscopical instruments should possess themselves of a copy of this very excellent catalogue. C. H. S.

Brightness and Dullness in Children by Herbert Woodrow, University of Minnesota. 322 pages. 12.5×19 cm. Cloth. 1919. J. B. Lippincott Company, Philadelphia, Pa.

This volume of the series entitled Lippincott's Educational Guides, edited by Dr. W. F. Russell, augurs well for the series. It is the most comprehensive study of the nature and causes of differences in intelligence which has been published. It is particularly valuable for its careful analysis of the results of mental tests. It combines accuracy of statement, some originality of interpretation and a clear and readable style. There are certain details which, in the opinion of the reviewer, are open to debate, but in the important issues, the author's position agrees with the best evidence and opinion.

Digitized by Google

VISUAL INSTRUCTION
WITH
SPENCER DELINEASCOPE MODEL 3

is made perfect because it is an IDEAL STEREOPTICON for both lantern slides and opaque objects, such as pictures, post-cards, reading matter and objects of all kinds dead and alive.

IDEAL, because it embodies basic ideas (patented) possessed by no other. Example: Mechanical means of handling the slides, which does away with the antiquated lantern-slide holder and at the same time gives a "dissolving effect" on the screen unattained with other outfits except by using two stereopticons, one above the other.

One Spencer Delineascope does it.

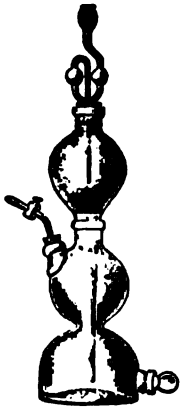
Spencers Delineascope Model 3 for both lantern slides and opaque objects. 1,000 Watt Mazda bulb illuminant. **Price, $185.00**

SPENCER BUFFALO U.S.A.

SPENCER LENS COMPANY
Buffalo, New York

Manufacturers of **Microscopes, Microtomes, Delineascopes, Optical Glass, Scientific Apparatus, Etc.**

SPENCER BUFFALO U.S.A.



No. 2402

We Carry a Complete Stock of

Chemicals & Apparatus

for the

Physical

Agricultural

Chemical

Biological

Laboratory

We Excel in Equipping High School Laboratories.
Let Us Quote Prices on Your Next List of Requirements.

THE KAUFFMAN-LATTIMER CO.

41 East Chestnut Street
Columbus, Ohio

Digitized by Google

The book opens with a brief and simple exposition of the mental tests which have been devised in recent years and which constitute the instruments by means of which we are now able with much greater definiteness than formerly to distinguish degrees of brightness and dullness. The meaning of brightness and the ways of designating or expressing it are next discussed. The next three chapters treat of the bearing of physical factors on intelligence. It is dependent chiefly on the character of the brain, but is influenced by physica defects and related to the rate and staces of physical growth. Closely related to physical and mental growth is the advancement in school or pedagogical age.

Following this discussion of the bearing of physical factors on intelligence is a series of chapters which compare the various special or particular mental abilities—as sensation, feeling, memory, reasoning—in their bearing on intelligence. Some of these are more closely related to each other and to brightness than are others.

The author finds heredity the prime factor in brightness and presents the evidence for this conclusion. In the concluding chapters he points out the necessity of giving different types of training to children of different levels of brightness and describes at some length the methods which have been found useful both at the upper and lower extremes.

FRANK N. FREEMAN, University of Chicago.

THE NATIONAL COMMITTEE ON MATHEMATICAL REQUIREMENTS.

At the last meeting of the General Education Board in New York, on February 28, the sum of $25,000 was appropriated for the use of the National Committee on Mathematical Requirements to continue its work for the year beginning July 1, 1920.

A preliminary report on "The Reorganization of the First Courses in Secondary School Mathematics" was published for the committee by the U. S. Bureau of Education about the middle of February. It has been distributed widely. Copies of the report have gone to all of the State Departments of Education, to all county and district superintendents in the United States and to all City superintendents in cities and towns of over 2,500 population. It has been sent to all the normal schools in the country, to some 1,500 libraries and to almost 300 periodicals and newspapers. In addition it has been sent to about 4,500 individuals, the names and addresses of which were furnished the Bureau of Education by the National Committee. This list of individuals consists chiefly of teachers of mathematics and principals of schools throughout the country. Additions to this mailing list to secure future copies of the reports of the committee can still be made. Individuals interested in securing these reports should send their names and addresses to the Chairman of the committee (J. W. Young, Hanover, N. H.).

A subcommittee, consisting of Professor C. N. Moore, of the University of Cincinnati, Mr. W. F. Downey, of Boston, and Miss Eula Weeks, of St. Louis, has been appointed to prepare a report for the Committee on Elective Courses in Mathematics for Secondary Schools. Any material or suggestions for this report may be sent directly to the Chairman of the subcommittee.

The recent work of the National Committee had a place on the program of the organization meeting of the National Council of Teachers of Mathematics held in Cleveland on February 24 in connection with the meeting of the Department of Superintendence of the National Education Association. Mr. J. A. Foberg of the National Committee on Mathematical Requirements was elected Secretary-Treasurer of the National Council.

Digitized by Google

Vol. XX. No. 6 S37 S4 JUNE, 1920 Whole No. 170

SCHOOL SCIENCE AND MATHEMATICS

A Journal for All Science and Mathematics Teachers

Founded by C. E. Linebarger

SMITH & TURTON, Publishers
Publication Office, Mount Morris, Illinois
CHICAGO OFFICE, 2059 East 72nd Place, CHICAGO, ILL.

CHARLES H. SMITH
EDITOR
Hyde Park High School, Chicago

CHARLES M. TURTON
BUSINESS MANAGER
Bowen High School, Chicago

DEPARTMENTAL EDITORS

Agriculture—Aretas W. Nolan
The University of Illinois, Urbana, Ill.
Astronomy—George W. Myers
The University of Chicago
Biology, Research in—Homer C. Sampson
The Ohio State University, Columbus
Botany—Worralo Whitney
Hyde Park High School, Chicago
Chemistry—Frank B. Wade
Shortridge High School, Indianapolis, Ind.
Chemistry, Research in—B. S. Hopkins
The University of Illinois, Urbana, Ill.
Earth Science—William M. Gregory
Normal Training School, Cleveland, Ohio
General Science—Fredric D. Barber
State Normal University, Normal, Ill.
Mathematics—Herbert E. Cobb
Lewis Institute, Chicago
Mathematics Problems—Joseph A. Nyberg
Hyde Park High School, Chicago
Physics—Willis E. Tower
Englewood High School, Chicago
Physics, Research in—Homer L. Dodge
The State University of Oklahoma, at Norman. Representing American Physical Society
Science Questions—Franklin T. Jones
Warner and Swasey Co., Cleveland, Ohio
Zoology—Harold B. Shinn
Schurz High School, Chicago

Published Monthly October to June, Inclusive, at Mount Morris, Illinois
Price, $2.50 Per Year; 30 Cents Per Copy

Entered as second-class matter March 1, 1913, at the Post Office at Mount Morris, Illinois, under the of March 3, 1879

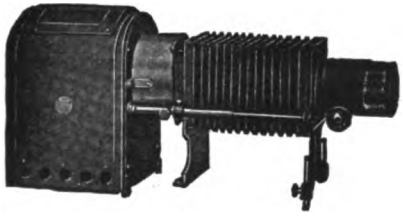
Digitized by Google

"McIntosh Lanterns Are Honest Lanterns."

Lantern Slides of Science

A copy of our Catalogs of science slides was mailed when published to every member of the Central Association. Are you a member? Did you get your copy? Did you keep it?

If not, there is another copy for you if you are interested. Just write us a card and ask for it. No obligation. You'll need it in placing your orders for science slides.



Lanterns from $43.00 up. Opaque and micro projectors, slides and accessories.

McINTOSH STEREOPTICON COMPANY
410 Atlas Block, CHICAGO, ILL.

Smith-Hughes Agriculture

IN A NEW SERIES

Moore and Halligan—PLANT PRODUCTION
—Agronomy and Horticulture

Tormey and Lowry—ANIMAL HUSBANDRY
—Care and production of farm animals

Vivian—EVERYDAY CHEMISTRY
—Soil fertility for plants and animals

FARM MANAGEMENT
—A proper combination of the above aspects of agricultural production

New York
Chicago
Cincinnati
Boston
Atlanta

AMERICAN BOOK COMPANY
330 East Twenty-second Street
CHICAGO, ILLINOIS

Digitized by Google

SCHOOL SCIENCE AND MATHEMATICS

VOL. XX, No. 6 JUNE, 1920 WHOLE No. 170

RESEARCH IN PHYSICS.

Conducted by Homer L. Dodge.

University of Oklahoma, Representing the American Physical Society.

It is the object of this department to present to teachers of physics the results of recent research. In so far as is possible, the articles and items will be non-technical, and it is hoped that they will furnish material which will be of value in the classroom. Suggestions and contributions should be sent to Homer L. Dodge, Department of Physics, University of Oklahoma, Norman, Oklahoma.

EINSTEIN'S THEORY OF GRAVITATION FROM THE STANDPOINT OF THE TEACHER OF PHYSICS.

BY JOSEPH S. AMES,

President American Physical Society, Johns Hopkins University, Baltimore, Maryland.

Few theories in physics have aroused the interest created by Einstein's theory of gravitation. Yet it should be noted at the beginning that Einstein has not proposed a theory, in the sense in which that word is used ordinarily. He has, on the contrary, proposed a new method of approach to the subject of physics as a whole. He has succeeded, starting from certain postulates, in deducing formulae which are most general in their application and from which far reaching conclusions may be drawn. Among the consequences of his postulates are: 1. A system of giving numerical values to the intervals of space and time; 2. The concept of energy having mass, both in the sense of inertia and in that of gravity; 3. The conservation of mass (and therefore of energy); 4. The conservation of momentum; 5. A law of gravitation, which degenerates to Newton's law if the velocities of the particles of matter are small compared with that of light; and many others. The laws of electro-magnetism are shown to be in accord with the postulates.

Digitized by Google

The essential things to emphasize, then, are Einstein's postulates and his method. It cannot be stated too strongly that no *theory* is involved. The teacher of physics is not called upon to revise his concepts, his methods, or his theories. He will learn from Einstein's work that there are new correlations and that care must be taken in announcing certain experimental results to call attention to the conditions under which they are true. Further, and most important, of all, he will learn that in speaking of a length, an interval of time, mass, etc., he is always limited to the *measured* values of these; no abstract ideas of "absolute" values are involved. For instance, if one says that the length of a rod does not change when it is held in different positions, east and west, north and south, vertical, etc., what is meant is that, if the length is measured in these positions, the same numerical value is obtained; no meaning being possible in the query: "Has the length really changed?" Or again, if one says, that the mass of a body depends upon its velocity, what is meant is that the numerical value for the mass obtained by measurement varies with its velocity.

With this introduction, Einstein's postulates may be stated and discussed briefly. The first of these is: "Every law of nature which holds good with respect to a coordinate system K must also hold good for any other system K′, provided that K and K′ are in uniform movement of translation." This is sometimes called the principle of relativity. One has an illustration of it, if he is sitting in a railway train in uniform motion and another train passes; it is impossible for the observer to decide by looking at the other train whether it has the relative motion observed, or whether his own train has it, or whether it is divided between these two. What is observed is simply the *relative* motion. The second postulate is: "The velocity of light in a vacuum is a constant, regardless of the source of the light, e. g., a star, the sun, a light-house."

It may be proved that these two postulates lead to a method of defining our methods of giving numerical values to intervals of space and time. Thus, if the length of a rod is to be measured, the process is for the observer to select a standard of length, e. g., a meter-bar, place it alongside the bar, note the readings on the bar of the positions of the ends of the rod, subtract one reading from the other; the observer, the rod, and the bar having no relative motion. It follows that, if this process is repeated on different days, or in different places, or by different observers,

Digitized by Google

the numerical value obtained is the same, provided only the condition specified in the first postulate is satisfied. This method leads at once to the idea of two equal lengths; and two equal intervals of time are then, in accordance with the second postulate, such intervals as are required for light to traverse equal lengths. In other words the principle of superposition is adopted in the method of measuring lengths; and what is meant by the words "uniform velocity" is "velocity of light"—this is a definition, and this concept combined with that of equal lengths leads to the definition of equal intervals of time.

There are many other consequences of these first two postulates, and among them, two are perhaps the most important; one refers to mass, the other to energy. If we analyse our method of giving a number to the mass of a body, we see, without too much difficulty, that the number assigned by any observer is obtained by the solution of two sets of equations, one stating the Conservation of Mass, the other, the Conservation of Momentum, in which last the "velocity" is that measured by the observer. When the two postulates are applied to these equations, it is found that the number to be assigned to the mass of any particle increases as its velocity is increased. The exact formula connecting mass and velocity can be deduced; and this has been verified experimentally. A consideration of this formula also shows that it may be interpreted as proving that energy has mass; the relation being that, if E is the amount of energy in a certain space and if C is the velocity of light, the mass associated with that space is E/c^2. Expressed otherwise, as Einstein himself states it, this leads to the conclusion that "inert mass is nothing else than latent energy." This refers of course to mass as an expression derived from inertia, and does not carry with it any conclusion concerning weight. (Einstein proved later, as a consequence of his other postulates, that energy had mass also from the standpoint of weight.)

The first postulate is limited to uniform velocities, and, as Einstein says: "Must the independence of physical laws with regard to a system of coordinates be limited to systems of coordinates in uniform movement of translation with regard to one another? What has nature to do with the coordinate system that we propose, and with their motions?" Obviously, as he says "the choice of systems of coordinates for our descriptions of nature should not be limited in any way so far as their state of motion is concerned." This is his third postulate. We may

Digitized by Google

express it differently by saying that, if we wish to express a law of nature by a mathematical formula, this last must retain the same form regardless of the coordinate system used for the purposes of description.

This new line of thought led Einstein to consider that phenomenon of nature which we call gravitation. Its simplest illustration is the case of a falling body. We know that this force due to gravity is independent of the nature of the matter constituting the body; it might be called a "geometrical" property. There is another illustration of such a geometrical property in the case of centrifugal force. Consider a so-called "conical" pendulum, that is, a heavy bob suspended by a string and so set in motion that the bob describes a horizontal circle, and the string, therefore, a circular cone with a vertical axis. To an observer on the ground there are two "forces" acting on the bob; its weight and the tension of the string. Now, if an observer were to be attached to the rotating system so that he turns with it, being stationed at the axis, he would find it necessary in describing what he observed to introduce into his equations a term called the "centrifugal force." No one attaches any "reality" to this concept, it is purely a fictitious quantity, used to simplify our mathematics. Now this centrifugal force is entirely independent of the kind of matter; and Einstein raised in his own mind the question, if centrifugal force is a fictitious quantity, introduced into the equations and experienced by an observer moving with a certain system of coordinate axes, but not needed and not experienced by an observer on the earth, i. e., using a different system of coordinates, why is not the same also true of the force of gravity? In other words, may not a set of coordinate axes be so chosen that with reference to them an observer would be unconscious of gravity and therefore would not introduce this force into his equations of motion? It is obvious that, if an observer were in a large box falling freely towards the earth, he would not know that he was falling, he would not be conscious of any pull on his body. Einstein expressed this in his fourth postulate: It is possible to replace the effect of a gravitational field at any point at any instant by a mathematical transformation of axes. This he called the "Principle of Equivalence."

From these last two postulates come many important consequences. One of these is that the space around any material body is non-Euclidean; e. g., if one could measure with sufficient

Digitized by Google

accuracy the length of the diameter of a circle and its circumference, the ratio of these two lengths would not be exactly π(3.14159+). Einstein deduced formulae which describe the motion of a particle in a gravitational field due to another particle, formulae which reduce to Newton's formula for the same problem provided the velocity of the particle is small, but which give a statement in accord with observation for cases to which Newton's formula has not been found satisfactory, e. g., the motion of Mercury. Einstein also deduced a formula for the curvature of a ray of light—the nature of which as an electromagnetic disturbance is known—when it passes through the gravitational field due to such a body as the sun; this formula has been verified by the observations made at the solar eclipse of last year. Other consequences of the postulates of Einstein are the conservation of matter, the conservation of momentum and the assertion that energy is indistinguishable from mass as regards both inertia and gravitation.

The method used by Einstein was simply to apply mathematical processes, making use of his postulates. Thus by means of his first two, he deduced the relationship between the coordinates (x, y, z, t) of a point as observed by a man moving with the system K and those of the same point (x′, y′, z′, t′) as observed simultaneously by a man moving with the system K′. These transformations give at once a means of discussing velocities, masses, etc. When he came to his study of the problem of gravitation, he was led to investigate the forms of equations which do not change their character when there is a transformation of axes of coordinates, and, from among these forms, to select the ones which would satisfy our knowledge of gravitation. It is difficult to say whether one admires more Einstein's concept of the problem and the proper method of approach, or his skill in applying his mathematical knowledge to accomplish his purposes.

Digitized by Google

THE SCOPE AND OUTLOOK OF VISUAL EDUCATION.

By J. Paul Goode,
University of Chicago.

We have grown so accustomed to the printed page as the foundation of school education, so satisfied with the old routine of assigning so much text, and demanding a reaction from the pupil in some oral or written test, that it may be actually something of a shock to have a change suggested. Yet we discover that the printed page is one of the slowest means of presenting a wide range of information.

One of the oldest studies in the school, geography, was the first to take advantage of visual methods. The map is a system of shorthand in the presentation, to the eye, of space relations. And yet it has never been made to give its best service to the pupil. In all geography rooms, globes and maps are essential, but the very great value of the desk outline map, to be filled in by the pupil, in exercises and tests on distribution, is a largely untilled field in education. We are not only eye-minded, we are hand- or motor-minded; and working on a map has possibilities in education, largely overlooked.

Very early the geographer introduced the picture, as an aid in the presentation of his subject. But it is only in recent decades that the value of the picture has been demonstrated in many other lines as well as geography. A reading book in the lower grades nowadays is unthinkable without generous illustration. All the sciences and arts use the picture and the diagram, in increasing measure. The growing generosity of illustration by the current magazines and certain daily papers has been a godsend to the schools, wherever live teachers have undertaken to collect and use these pictures. One of the best services has been that of the National Geographic Magazine. Its collection of pictures, now over fifty thousand, are being reprinted, and made available at cost for individual pupil's use.

The success of this picture phase of visual education has been marked. But the pictures are as a rule too small for class use. This early led to the use of the projection lantern. But the lantern of early days was a cumbersome thing. The coming of electricity gave much more freedom, but even here the danger of open circuits, and the attention to the open arc have kept the equipment out of common use.

The coming of the Mazda filament lamp, however, has thrown

Digitized by Google

all barriers down. The lantern is coupled into any lamp socket, it can be safely managed by any child, the light is so intense that the darkening of the room is not a serious matter. By means of the reflectoscope, book and magazine illustrations become available also.

The lantern makes possible and profitable the use of many maps and graphs as well as pictures. A map can be copied into a lantern slide, and colored for a dollar or so, and thrown on the screen on a scale much larger than any printed map obtainable. This gives unlimited freedom to the instructor, for many maps which we may never hope to have published in large form could be used with profit in the classroom.

The graph is a device in visual education which has large possibilities, and is but little developed. A whole page of statistics can be thrown into the form of a curve, as for example, the production of wheat year by year for a generation, and the trend of production can be read at a glance. One may notice the conspicuous success of the Babson curves of business expansion and depression, and the growing use of graphics in many lines of business, to realize something of the possibilities of this form of visual education.

The finest service yet rendered in the schoolroom has been done by the stereograph. The photograph presents but two dimensions. But the stereocamera and the stereoscope work a miracle. They supply the actuality of binocular vision, and the third dimension is presented to the eye in vivid reality. The person who looks through the stereoscope looks upon the real mountain, looks into the depths of the real canyon, looks upon the actual statue, the actual cathedral.

The genius who learned how it could be made best to serve the purpose of schoolroom work is Mr. B. L. Singley of Meadville, Pennsylvania. In this development I have a personal, almost a fatherly, interest. It is now sixteen years since Mr. Singley came to me, to tell me of the opportunity for service which he could see in the stereoscope, and for consultation on the problem of adapting it to school needs. The needs of the classroom, and the possibilities of development of the stereoscope appealed to me, and my counsel and suggestions for development were gladly given. And so I have had always a personal pride in the development of the system. Mr. Singley discovered that the stereograph must be worked, but not overworked. It must help get the day's lesson, not get in the way

Digitized by Google

of the lesson. It must occupy the student without the attention of the teacher. It must lead the pupil to apply himself, and learn for the pleasure of learning.

The method is simple. An ample supply of stereographs is provided. The number in one standard set runs to 600. The subjects are chosen to cover the whole earth, and with selections so made as to cover many topics which will be studied in geography, in history, in literature. These stereographs are classified into all the topics where their use may be profitable; cross referenced, and indexed, and the whole study published in book form, as a Teachers' Guide, so that the teacher may find any stereograph available for teaching any subject, as easily as she can find a word in the dictionary, and can put her hand right on the required stereograph without a moment's delay.

Each stereograph has on the reverse side a description running to 250 words, written in an interesting style, and carrying the necessary information to the student. In use, the teacher puts out the stereoscope and one or two stereographs relating to the next day's lesson. Some time during the study periods of the day, each pupil will study the stereograph, read the description, and be ready next day to tell what he saw. It becomes a game to see who can stand and report in good English what he saw, looking through the window of the stereoscope into the reality beyond. At the end of the week, or when the review on the country or topic comes, the same views, in lantern slide form, are put before the whole class, and some pupil is chosen to stand before the class and discuss what one view presents, and other pupils report on other slides.

A real interest is aroused. Better teaching results. Live material is in hand always, for drill in geography, history, English. The success of the method is unquestioned. The sets of views are in use in thousands of schools all over the country. It is the best contribution yet made in visual education in America.

The stereograph arrives at perfection, in presenting the perception of solidity, and distance, the *third dimension* of the view. There is nothing to compare with it in this service, but it is a static world. Motion is absent. Yet *motion* is another "dimension," and the presentation of motion in the picture is an arrival at another apex of perfection. The gracefully moving animal, the rushing waves, the swaying trees, are all there, to the last perfect detail of motion.

Digitized by Google

Since education comes through arousing the interest of the child, and since the power of the movie to arouse interest is patent to all, it has occurred to many people to draft the movie into the service of the schoolroom. Every trial has shown some measure of success, but always some critical drawback has arisen to block progress. The flickering light on the screen is hard on the eyes. The projection machine is very expensive. It uses a large current, which may be dangerous, especially as it is likely to set fire to the film. That puts it under ban by the insurance interests, and an expensive housing or shelter is required. This restricts its use to the auditorium, and this in turn takes it out of the reach of class work. The films are very expensive, and for the most part have been made with the one aim of entertainment or of advertisement, so may not be satisfactory or even usable for purposes of instruction. In short, the whole matter up to the present moment seems like an exhibition of misfit effort, showing a lack of intelligent cooperation on the part of the interests directly involved.

And now comes another genius, in the person of Professor Forest Ray Moulton of the University of Chicago, one of the leading mathematicians of the country. Professor Moulton found that the standard projection machine is very inefficient, the screen being lighted only one-tenth to one-third of the time, the other nine-tenths or two-thirds of the time being in darkness. Hence the flicker. He invented a new movement, reversing the ratio of service, having the screen illuminated nine-tenths of the time, and the *flicker disappears*. Not only this, but the motions are smooth and natural, not jerky.

Since only about a tenth of the current hitherto used is required, the machine for a classroom can be coupled into any lamp socket and operated by a child. The machine can be stopped at will and held at any point for study and discussion with no danger of setting fire to the film.

With these advantages in hand a Society for Visual Education has been formed for the purpose of solving the problems in the adaptation of the cinema to purposes of instruction in the schools. All sorts of tests and measurements will be made, to find out the place and best service of each of the devices in visual education, in the administration of the school program.

Now let us make no mistake as to the efficiency of any or all the devices which may be used in visual education. No one of them or all of them will ever take the place of the live, earnest

Digitized by Google

competent teacher. Moreover the best of teachers will have to be initiated into the best methods of using the graphic material. All of the visual devices together will not remove the need of effort or work on the part of the pupil. The pupil's real achievement will be measured by the attention and effort of the pupil. But the visual helps will create interest, stimulate attention, and reduce effort so more ground may be covered in a given time. So also may a higher record of achievement be won by a larger number of pupils.

And this brings us to the economic phase of our quest. It will pay school boards to invest in the proven methods of visual instruction. The Racine, Wisconsin, schools in 1910 compared well with the schools of other cities of similar size, the country over. Their record of pupils failed at the end of the year was low—only one in ten of the pupils below the high school. A ten per cent failure was to be expected. In 1910 these schools began to adopt the stereographic equipment called the 600 Set, and the failures began to decrease. Rooms began to make a record of no failures at all during the year. In 1914 the Russell Sage Foundation made a wide study of "failures and promotions" and the Racine schools were recorded as showing an average of five per cent of failure. The survey also brought out the fact that in the schools where the new system of visual education was not used, the record still stood at ten per cent. In the 5,000 children in the Racine schools, between the kindergarten and the high school, cutting the failures from ten per cent to five per cent gave promotions to 250 pupils, who without the improved instruction would have been ranked as failures and would have been required to repeat the course. To have had 250 pupils repeating the course would have called for six or eight extra teachers, and extra rooms. On the basis of the average cost of a year's schooling, this promotion of 250 pupils was a saving to taxpayers of Racine of between $10,000 and $15,000 in the year. Think of what the saving to the whole country will be when visual education has been fully worked out and entered in all the schools.

There are in the common schools of the country at this time, in the grades below the high schools, over 20,000,000 pupils enrolled. The record shows over 15,000,000 in attendance. The average annual cost per pupil in these schools in 1914 was not far from $30 each. This cost has doubtless doubled since then. An average of ten per cent failure in this number gives

Digitized by Google

us about 1,500,000 pupils to repeat the work. This, at $60 per pupil, makes the very respectable sum of $90,000,000. Suppose now, the introduction of visual education could cut this failure record down to five per cent on the average. That would make a saving of $45,000,000, a prize well worth working for. Not only can this improvement be made in the grades, it can be made in some measure in the secondary schools as well. The equipment thus made ready may serve in Americanization work, in churches, and in Community Centers. This is a wide and magnificent opportunity for service. It is worthy the best brains and most serious effort of all of us.

THE AURORA OF MARCH 22, 1920.

By Lewis J. Boss.

In the early evening of March 22 there took place the most spectacular display of aurora borealis that has occurred so far this year. When first seen at about 7:30 p. m., a wide ribbon-like, waving curtain of green light extended in a huge arc across the northern sky, well over the constellation Cassiopeia. From this arch pulsating streamers shot towards the zenith and seemed to converge in a point directly overhead. At times the edges of some of the streamers and of the curtain bands would show a decided crimson tint, which would waver and flare like the flame of a dying fire. Maximum activity seemed to be reached at about 8:00 p. m. and then the display began to die down. Soon, however, the height and brilliancy of the streamers began to increase once more and by 8:05 p. m. it became evident that another outburst was about to take place, which would equal if not surpass the first.

The phenomena this time took the form of a wide wavy curtain of light, ever shifting and weaving in and out, over which rosy-pink patches of light traveled slowly toward the east and faded out, only to begin again at the north and repeat the performance. At 8:10 p. m. the magnetic needle showed marked perturbation, swinging toward the east five or ten degrees, and once showing a shift of twenty degrees. During some of the more brilliant flashes a distinct snapping or crackling sound could be heard. These manifestations continued for nearly ten minutes, after which their intensity rapidly diminished, and by 8:20 p. m. only a few pale green wisps of light remained quivering in the north. The aurora did not cease, however, but with occasional fits and starts continued until the early morning of March 23. One of the features of this exhibit was the occurrence of several intensely bright green areas of light almost sixty degrees from the horizon, and of a brightness equal to that of the full moon.

On March 23 I observed the sun and noted a row of five large spots and several smaller ones. This is a larger number of spots than I have seen on the sun lately. This was the best auroral display we have had here in two or three years, in fact I do not recall having seen an aurora which was as bright as this one in a long time.—[*Popular Astronomy.*

Digitized by Google

MAPPING BY AERIAL PHOTOGRAPHY.[1]

By W. H. Spurgin,
Hyde Park High School, Chicago, Ill.

No one, who has a most casual interest in maps, can glance at the ground from an airplane in flight without the feeling that he is looking at a vast colored map, which, in its wealth of detail of land and water, of railroads, highways and paths, of forest and cultivated ground, of buildings and towns, in its absolute accuracy and up-to-dateness, should be the envy and despair of every professional map-maker. So striking is this resemblance that it could hardly have failed to occur to balloonists years ago that a map could be very easily made with a camera.

Much has been written concerning the importance of aerial photography in the war; and the limits of this paper do not permit of a full discussion of that topic, interesting though it might prove. Yet, since the science of aerial photographic mapping owes by far the greater part of its growth to the war, we must glance for a moment at some of the uses to which it was put.

The Germans seem to have started using hand-held cameras early in the war with, of course, no attempt at systematic mapping, but these were quite unsatisfactory, largely because the leather bellows caved in under the strong air currents, and soon a metal camera with fixed focus and focal plane shutter was devised and attached to the fuselage. Plates were carried in magazines, and exposures and changes of plates made by hand. Development was rapid to a highly perfected type, using roll films, kept flat by suction, and capable, when adjusted for altitude and speed and set in motion, of making automatically 100 successive exposures at any desired time interval, the power for operation being supplied by a small fan propeller working like a wind-mill.

Complete photographic maps of the zone of activity formed the basis of operations in each sector, and squadrons of reconnaissance planes were employed keeping them up to date. In time of great activity large sections would be re-photographed every day, while particular points might be photographed every two or three hours, and the series carefully studied for any changes. Not only were these photographs extensively used at

[1]Read before the Earth Science Section of the Central Association of Science and Mathematics Teachers, November 29, 1919.

Digitized by Google

headquarters, but copies were given to infantry officers when an attack was planned, and to the artillery for checking up the effect of their fire. Photographic expeditions were carried far back into the enemy territory for the purpose of mapping lines of communication, camps, ammunition and supply dumps, flying fields, and the like. The occasional value of a single photograph is seen when we are told that on one occasion twelve French planes, carrying twelve pilots and twelve observers were dispatched at 15-minute intervals in an attempt to obtain one picture. Perhaps we should notice, before leaving this topic, that accurate base maps were continually used as a basis for, and a check upon, the photographic maps, they not being of sufficient accuracy otherwise.

The range of a flyer's vision is perhaps not commonly realized. By applying the theorem of the secant and its external segment as related to the tangent we find that, at an elevation of one mile, the horizon, in comparatively flat country, is 89 miles distant, and that that distance increases as the square root of the altitude. Thus, on a perfectly clear day a flyer 6500 feet above Lansing, Michigan, could easily see portions of L. Michigan, L. Huron, and L. Erie; while if Rohlf, on his record altitude flight last September, of 34,610 feet, had been over Lake Huron he could actually have seen in one sweeping glance all of Lakes Huron and Erie, more than half of Lakes Michigan and Ontario, and a considerable portion of Lake Superior.

The area included within a single photograph depends, of course, upon the altitude, the focal length of the lens, and the area of the plate. While lenses of 48-in. focal length were used where a detailed view of some object such as an enemy battery was desired, and anti-aircraft guns made considerable altitude necessary, the most satisfactory lens for general mapping was the 10-inch. With this lens, and an elevation of 10,000 feet the image is approximately on the scale of 1-12,000. An 8x10-in. plate, then, would cover an area about 2 miles long and 1.6 miles wide. When a continuous map of a larger area is desired the pilot flies in a straight line, taking pains to retain the same altitude, and to keep the plane horizontal to avoid distortion, while the observer makes exposures at an interval calculated to give 1-4 to 1-3 overlap. The prints are then carefully matched and pasted together, forming a mosaic. As many strips as are necessary may be photographed in this way and a complete map built up of any desired area.

Very little aerial mapping has been done in this country.

Digitized by Google

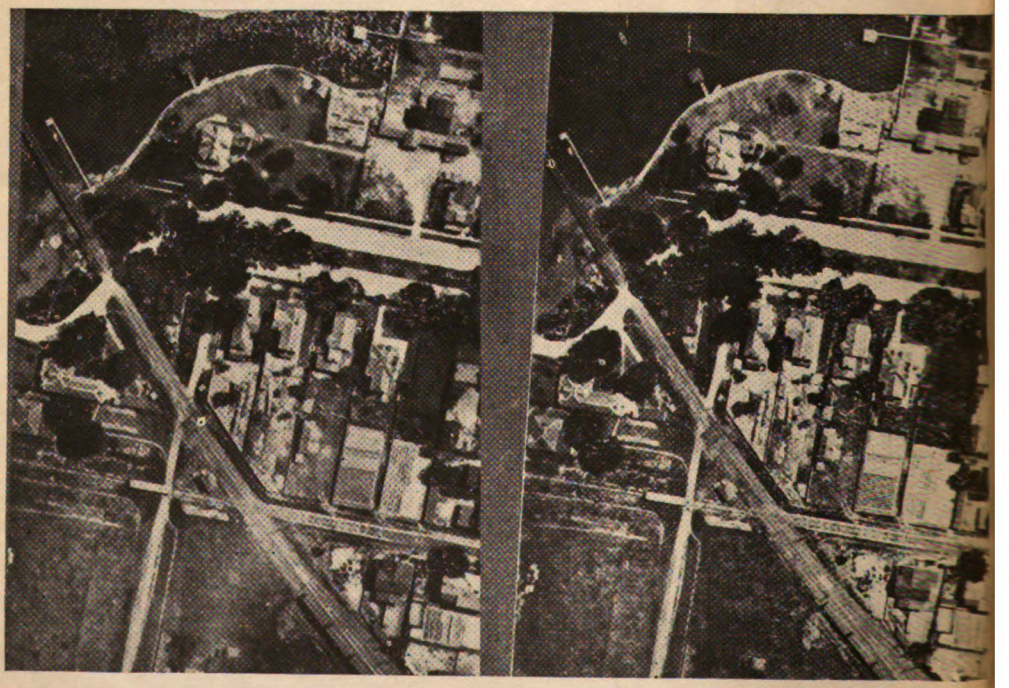
During the war a few such maps were prepared by photographic units in training, the largest being of the vicinity of Ft. Sill, covering an area about 35 miles by 10 miles. Another, somewhat smaller, but of more interest to geographers, covered a portion of the alluvial fan region of Southern California. The work of mapping routes connecting the various flying fields was started but not completed. During the past summer a squadron was engaged in making a mosaic 20 miles wide of the route between Oklahoma City and Fort Sill, a distance of 80 miles. 30,000 plates will be exposed, and the completed map will be on the scale of about 1 foot to the mile. Another squadron is mapping coast-to-coast aerial routes.

It may seem at first thought that an aerial photograph, taken from vertically overhead might be held in any position for study. In this picture (see insert), the trench system runs along a pronounced crescent-shaped ridge; in front, a row of mine craters; behind, dirt thrown out from dugouts, and down the slope. If we turn the picture upside down I think you will observe a persistent attempt on the part of the trenches to disguise themselves as stone fences in a valley, while the mine craters and shell holes are neatly turned wrong side out. The explanation of the reversal of slopes seems to lie in the fact that in all of our experience with photographs of landscapes, as well as with landscapes themselves, the shadows fall, in general, down. If a picture is held so that the shadows fall up our mind refuses to accept the new situation and insists upon interpreting the slopes in such a way as to fit our pre-conceived notions of downward-falling shadows. The same effect may sometimes be seen on an ordinary terrestrial landscape view, particularly if it has well defined shadows and no prominent artificial objects.

Perhaps some of my hearers have been struck by the apparent flatness of the country in aerial photographs. It is true that all relief disappears at a comparatively low elevation unless the sun is at such a low angle as to bring it out by shadows. Much may be inferred from the course of roads and railroads, from the direction of plowing where contour plowing is followed, and from the streams, but nothing definite as to elevations. The writer spent the greater part of the summer of 1918 at Eberts Field in the rice district of Arkansas. The land is extremely level, but still the rice-growers find it necessary to throw up dikes along the contour of the surface to retain the standing water on the growing rice. When viewed from an elevation

Digitized by Google

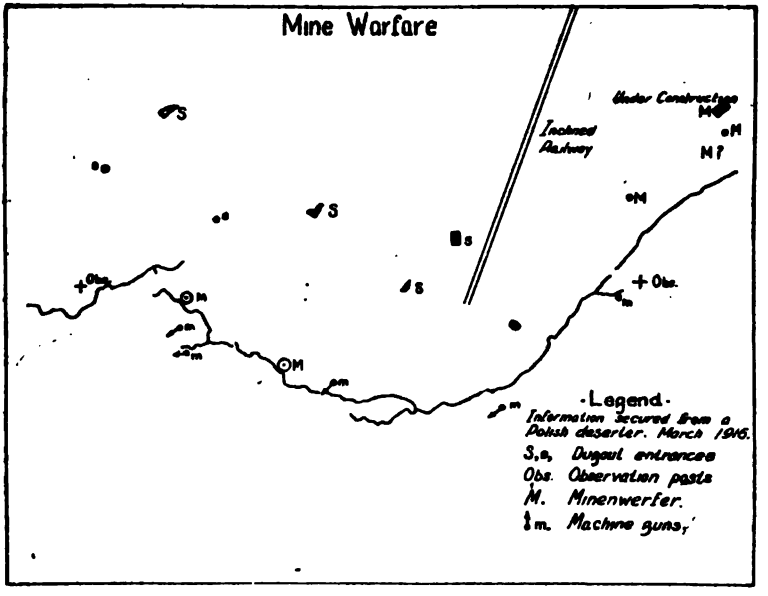
Digitized by Google



STEREOSCOPIC VIEW OF WATER FRONT AT HAMPTON, VA.
This picture may be cut out, mounted on cardboard, and viewed through an ordinary stereoscope.

Digitized by Google

of 2,000 or 3,000 feet as perfect a contour map as one could desire is formed by the dark green color of the rice as it grows on the dikes, contrasted with the brighter green of that growing between the dikes. If contours were everywhere so easily discerned the problem of showing relief in aerial photographs would be solved. But, unfortunately, resort must be had to other means.



We are all familiar with the principle of the stereoscope. Obviously an ordinary stereoscopic camera with lenses about 2 3-4 inches apart would be of no value in aerial work, for the effect practically disappears at a little more than 100 feet, and it would reveal no more relief than could be seen by the observer. But, if the lenses of such a camera are more widely separated, the stereoscopic effect is exaggerated. For our present purpose the separation would have to be greater than would be possible on an airplane; so the result is obtained by taking photographs in the same way as for a mosaic, except that more overlap is allowed. The portion that is common to both prints may then be mounted as a stereo. As a matter of fact, the stereo was of such value in military work that in much of the photographing an overlap of 1-2 was allowed so that the interpretation could be done largely by use of the stereoscope. Nor is it necessary to make careful mounts, as the prints may be run through a

Digitized by Google

cardboard with slits and quickly adjusted for any particular object. One or two examples will serve to illustrate the use of stereos in the war. Shell holes were frequently covered over with camouflage to conceal machine gun or battery positions. While these particular shell holes looked no different from others in an ordinary view, they immediately became conspicuous in a stereoscopic view by reason of their lack of depth.

The most striking thing about aerial stereos is the great exaggeration of the relief. Ordinary houses assume the proportions of skyscrapers, box-cars of grain elevators, and ordinary trees of palm trees. The rule was given that views intended for this purpose should be taken at an interval of 1-8 the altitude, but a greater or less interval merely increases or decreases the stereoscopic effect. Interchanging the right and left sides of a stereo changes all elevations into depressions and we have the effect of looking into the plaster casts of the buildings.

We may now turn our attention to the future of this new art. May we accept at their face value the claims of the most ardent supporters of aerial mapping to the effect that it is soon to displace all other methods of mapping? There can be no question that, for completeness of detail (apart from relief) the aerial photograph leaves little to be desired. Nor can we conceive of any other method whereby all this detail could be obtained with anything like the ease and speed. But, desirable as these features are in themselves, the first thing to consider in any system of mapping is accuracy, and here we open the door for a host of disturbing factors.

Let us look first at the physical difficulties involved in securing the picture. The camera is more or less rigidly attached to the fuselage which necessitates that the plane, at the moment of exposure, be perfectly horizontal; otherwise, the plate will not be parallel with the ground, and distortion will result. Furthermore, in making a mosaic, all the exposures must be made at exactly the same altitude. Both of these conditions call for very skillful piloting. To be sure, pictures taken at differing altitudes may be enlarged or reduced to the same scale, and even those taken at an angle may be rectified, but that requires an accurate base map of the region. Some device may be developed which will retain the camera in its proper position regardless of the attitude of the plane, but we must bear in mind the instability of the support itself. The use of small dirigibles instead of airplanes would to some extent obviate

Digitized by Google

this difficulty by reason of their ability to hover over a point, thus enabling the observer to work more leisurely.

Again, a low altitude requires either a wide angle lens to cover territory, or a much larger number of exposures. But high altitudes, above 10,000 feet for instance, involve temperature changes which are likely to disturb the focus and retard the action of the moving parts.

Fog and haze are a hindrance, but the use of color sensitized plates and color screens, which were developed by the Bureau of Standards during the war, have wonderfully reduced this difficulty.

The focal plane shutter introduces another error which may not be disregarded. This arises from the fact that the plate is not all exposed at once, which causes an elongation in the direction of flight.

Let us suppose, however, that by one device or another these technical difficulties have been surmounted. Certain inherent weaknesses still remain. In a hilly region the hilltops, being nearer the camera, will photograph larger. Thus, if the camera is 10,000 feet above a valley, and a neighboring hilltop is 2,000 feet above the same valley, the lengths of the images of equal distances on the two will be in the ratio of 8-10. Furthermore, hills not in the center of the picture will appear to lean away from the center, particularly so with wider angle lenses, and more noticeably so the farther away from the center.

In view of these shortcomings it seems quite certain that where accuracy, say of one part in 10,000, is a requirement, photographic mapping cannot supplant the more laborious methods. But that does not mean that it may not become a very valuable aid to these established methods. Given a base map with a sufficient number of control points, cultural detail may be gathered with amazing speed, completeness, and ease. Scarcely forty per cent of the area of the United States has been satisfactorily mapped. Surely much of the detail of the remaining work may be obtained from the air. Old maps may be brought and kept up to date. Changing coast lines may be mapped with sufficient accuracy and as frequently as necessary, or may be roughly surveyed to determine whether remapping is needed. It is even possible that the configuration of the bottoms of shallow bodies of water may be evidenced by varying shades, although the extent to which this will be possible is somewhat uncertain. Difficultly accessible regions, such

Digitized by Google

as swamps, may be mapped approximately. Preliminary surveys may be made of unmapped areas which will serve until accurate base maps can be prepared and the aerial map may then be transferred and corrected.

One of the oil companies which has large holdings in British Columbia had spent a considerable sum exploring a mountainous region in search of a pass through which a pipe line might be run. A year ago they were considering making an aerial survey. Whether the plan was carried out I am unable to state.

Considerable stand of wood-pulp timber was located during the past summer in and west of Labrador by an aerial reconnoissance party. Some 13,000 plates were exposed.

Those of you who have seen the stereos will realize that even topography may be sketched in roughly. It has been suggested that conspicuous monuments of known height might be erected over the region to be mapped, which would serve as standards. Instruments which have been in use in connection with stereoscopic mapping of some of our western mountains may then be used to determine the elevations of conspicuous points by measuring the stereoscopic effect, and the contours then sketched in.

Perhaps no more appropriate use could be found for the aerial camera than the mapping of air routes. One could ask for no better map of the country over which he is to fly than its picture. Nor would he be concerned with absolute accuracy. And there seems to be good reason for believing that air travel, on a commercial basis, will be largely confined to fairly definite lanes in order to take advantage of established landing fields. Here, certainly, photographic mapping has a field which is peculiarly its own, and a future which is limited only by the future development of aerial navigation.

THE GREAT POTASH DEPOSITS OF GERMANY.

The potash deposits of Germany, which were discovered by the Prussian Government in 1843, at Stassfurt, while boring for rock salt and which occur in upper layers of rock salt in the plains of northern Germany, have been estimated to occupy a volume of 10,790,000,000 cubic meters and to contain 20,000,000,000 metric tons of potash salts, corresponding to about 2,000,000,000 metric tons of potash (K_2O), a quantity sufficient to supply the world for 2,000 years at the present rate of consumption. These beds, according to the United States Geological Survey, Department of the Interior, were first exploited about 1860, and have furnished practically the entire world's supply of potash for many years.—[*U. S. Geological Survey.*

Digitized by Google

A NEW DIRECT READING VACUUM GAGE.

By W. H. Farr,

Central Scientific Company, Chicago, Ill.

When the Central Scientific Company began producing the Cenco-Nelson Vacuum Pump in quantities one problem which presented itself to the laboratory was that of a satisfactory routine test of the vacuum produced by this pump. The chief requirements of such a test are, that it must be quick, reliable, and "foolproof." The McLeod gage was used for some time, but there are some objections to its use as a routine test in quantity production. In the first place it is rather slow. It not only takes a little time to fill the bulb and empty it again but besides it is necessary to take a series of readings over a period of time to see whether or not the vacuum is improving. Furthermore the apparatus is rather delicate for routine use, and can be easily ruined by careless handling. If oil is accidentally allowed to get into the bulb, the cleaning and drying of the glassware involves considerable loss of time. In case the glassware is broken or if mercury is spilled, renewal or recalibration is rather expensive. In view of these facts, the laboratory began to investigate other means of measuring a vacuum, which would be more suitable for our conditions.

The variety of effects displayed by electrical discharges in rarified gases suggested the idea of using some of these phenomena to indicate the degree of vacuum produced by a pump. The problem was to determine which of the characteristics of the vacuum discharge could be measured quantitatively with sufficient accuracy to serve as a measure of the vacuum.

Of the two sizes of the Cenco-Nelson Pump (2 stage and 3 stage) the 2 stage is guaranteed to produce a vacuum of .10 mm. and the 3 stage of .05 mm. Occasionally a 3 stage pump will be found which will go as low as .02 mm.

Before a vacuum of .10 mm. has been reached the Faraday's dark space has become well defined, and occupies a considerable portion of the tube. The positive column is broken up into well defined striations, which become larger and fewer as the vacuum improves. It was first attempted to use the length and form of the positive column as the quantity to be measured. This gives a fair indication of the vacuum, but is not sufficiently reproducible to serve as a reliable test.

It is affected by such factors as the size and proportions of the tube, the form of the electrodes, the dryness of the tube and the

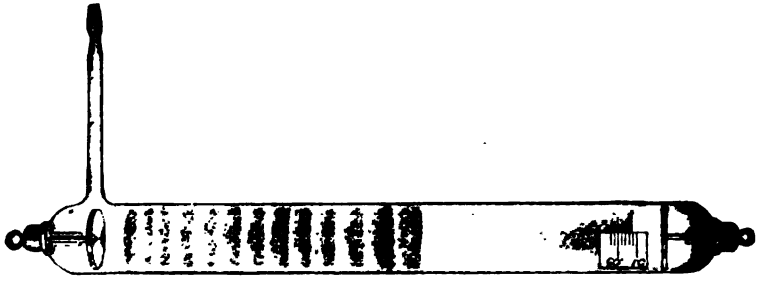
Digitized by Google

frequency of the current. This unreliability is especially noticeable in the neighborhood of .05 mm. and above, which is just where the greatest accuracy is desired.

Another phenomenon which was investigated was the appearance of the apple green fluoresence which indicates the beginning of the production of cathode rays. The difficulty here was that there is nothing about this color which can be measured quantitatively, and its appearance is affected by some of the conditions of the test, such as the condition of the tube, the shape of electrodes and the strength of the spark coil.

An attempt was made to test the vacuum in the tube by measuring the current flowing through the tube with a hot wire milliammeter, but this method was abandoned. It was also attempted to use a spark gap in parallel with the tube, the length of the gap to be adjusted so that it would spark over at the desired vacuum. The resistance of the tube proved to be too low for this method to be a success.

It was finally found that the most satisfactory characteristic of the vacuum discharge to be measured quantitatively is the Crooker dark space. This dark space begins to appear around the negative electrode at a vacuum of about one millimeter and increases up to a vacuum of about .02 or .01 when it becomes too hazy and indefinite to measure. The dark space is most easily measured in a tube having disk shaped electrodes. In such a tube it appears as a cylindrical shaped space with a well de-



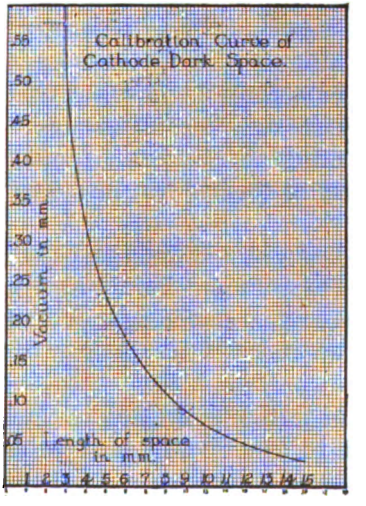
fined edge, as shown in Fig. 1, whose length can be measured with an accuracy of about 1-2 mm. It will be noted that the range over which this dark space is measurable covers the range of the vacuum produced by the Cenco-Nelson Pump.

To determine the reliability of the measurements of this dark space as an index to the degree of vacuum, it was necessary to determine how much it is affected by the conditions of the test,

Digitized by Google

such as the individual characteristics of the tube, voltage of the battery, frequency of the vibrator, voltage of the coil, etc. It was found that the length of the dark space is not affected by the diameter of the tube but there is a certain relation between the diameter of the electrodes and the diameter of the tube, and also between the length of the tube and its diameter, which gives the most clear and definite reading.

To determine if the dark space varies from one tube to another depending on the individual characteristics of the tube, a number of tubes were made up, as nearly indentical as possible in form and dimensions. These were calibrated by the McLeod gage and the measurements compared. It was found that in tubes of the same form and dimensions the length of the dark space is an accurately reproducible quantity. The effect of the voltage of the coil and the frequency of the vibrator were also investigated. The only effects of changes in the voltage of the coil is to vary the intensity of the discharge, it having no effect on the length of the cathode dark space. The same is true of the frequency of the vibrator.



The relation between the length of the dark space and the vacuum is shown by the curve in Fig. 2. It will be noted that the rate of change in length becomes more rapid as the vacuum becomes higher. This is a decided advantage, as it makes the accuracy of the readings increase as the vacuum increases. In the tests of the Cenco-Nelson Pumps the readings come near

Digitized by Google

the lower end of the curve, at which point it is easily possible to graduate the scale on the tube to read .01 mm. directly, which is a satisfactory degree of accuracy for this test.

During the development work on this test, all the work was done in the dark room. When it was perfected, however, a shade was constructed which made it possible to use the equipment in daylight. This was in the form of a wooden box whose dimensions were slightly larger than those of the tube, and which was painted black inside and outside. The tube is observed through a wide slot in the front side. The tube is held in spring clips, so that it is easily removable, and the connections are made through binding posts on the outside.

In conclusion, the specific advantages which are claimed for this test are the following:

1. As the connections are shorter and there is a smaller volume of air to exhaust, the desired vacuum is reached more quickly than when using a McLeod gage.
2. The reading is instantaneous, whereas some little time is required to read a McLeod gage.
3. This test gives a continuous indication of the vacuum, while with the McLeod gage it is necessary to take a series of readings to determine whether the vacuum is improving or not.
4. As the scale on the tube is direct reading, it requires no experience or practice to interpret the result, nor is there any source of error due to a zero setting.
5. The accuracy of this method increases with the degree of vacuum.
6. This test does not require the handling of mercury or expensive glassware, making it more suitable for a routine test.
7. The complete apparatus is light and portable.
8. In case of breakage of the glassware, renewal is not expensive.
9. A number of testing sets can be operated from the same coil and battery, it being only necessary to duplicate the vacuum tube.
10. The accuracy of the test being independent of the voltage or frequency, there are no meter readings or corrections.

Digitized by Google

CONSULTATIVE WORK IN GEOGRAPHY AS A MEANS OF IMPROVING ITS TEACHING.

By Alison E. Aitchison,

Cedar Falls, Ia.

It is being realized more and more fully that to improve, immediately, the work which is being done in geography in the elementary schools, some effort must be made to help the teachers while they are in service. Many of them have neither opportunity nor time to stop teaching and take courses in college or normal school. Many more have attended such schools and have taken no courses in geography, either because it was not required or because they considered it a subject which anyone could teach without special preparation. So into the grades they went from high school and college to teach geography, they themselves not having touched it, or anything akin to it since they left the seventh grade. In the meantime, great changes have taken place, not only in the subject matter of geography but in the methods of presenting it.

Endeavoring to meet these conditions, which exist everywhere, the Extension Division of the Iowa State Teachers College sends out through the state a member of the geography faculty, to do what is termed "Consultative Work in Geography." Of course the number of places which can be taken care of in any one year is very limited. A schedule is arranged allowing the consultative worker to spend from two to four days in a school system, the number of days varying with the size of the town.

On meeting the city superintendent, the first morning, a general program is laid out. This is often changed greatly as individual teachers ask for help along some special lines. The visit of the consultative worker is much more satisfactory to all, when the superintendent and teachers have discussed the plan beforehand and know the purpose of the consultative work and what they may hope to gain from it.

Generally the first day is spent in visiting classes. This gives the visitor an idea of the course of study and the quality of the work being done, besides enabling him to meet the individual teachers and judge to some extent their problems. The program is so arranged that classes in geography can be visited at every period from nine till four. Thus by the time school closes one has a fairly good idea of the work in two or three different buildings. The superintendent and the principal of

Digitized by Google

the building visited are generally present at all recitations.

After school, from three-thirty or four o'clock to five or five-thirty, a conference is usually held with the teachers, principals and superintendent. At this time some of the general principles of geography teaching are discussed, and the teachers bring up questions pertaining to their own particular grades, dealing either with subject matter or with methods of presentation.

The second day is most frequently spent in demonstration teaching, either before all the teachers of a certain grade at one hour and those of another grade at another hour or before all the teachers of one building at one time. In larger places two days are given to this work, since it is not easy for all the teachers to meet at one building. The demonstration teaching is followed always by a discussion, sometimes a very lively one.

Slightly different problems present themselves at each place. Some schools are working out a new course of study and the superintendent requests help on that. Effective work may be done in that way as few superintendents have either the time or the detailed knowledge of geography to enable them to plan a course in the subject which will be really helpful to inexperienced teachers. Most of the courses simply say "for the fall term course — pages — to — in — the first book of —."

In other schools little supplementary material and few wall maps are on hand, and suggestions for their selection can be made. Often conferences are held with individual teachers, who ask for help in the improvement of their own classroom work.

The experience of many Iowa schools shows that here is a method that may be applied to any state, yet so far but little advantage has been taken of it, of reaching the teacher just when she feels the greatest need of help and is willing to ask for it. If we believe that geography can bring something to the child, that no other subject can, we must make immediate efforts to see that it is made to occupy a more significant place in the curriculum of every elementary school.

Digitized by Google

RESEARCH IN CHEMISTRY.

Conducted by B. S. Hopkins,
University of Illinois, Urbana.

It will be the object of this department to present each month the very latest results of investigations in the pedagogy of chemistry, to bring to the teacher those new and progressive ideas which will enable him to keep abreast of the times. Suggestions and contributions should be sent to Dr. B. S. Hopkins, University of Illinois. Urbana, Ill.

THE POSITIVE ELECTRON AND THE BUILDING OF ATOMS.

By William D. Harkins,
The University of Chicago.

(*Continued from May*)

The composition of the heavy atoms may be found in a paper by the writer now in print in the *Physical Review*.

Why The Atomic Weights Are What They Are.

The writer has developed a theory in addition to that given above, which tells why the atomic weights vary on the whole as they do, but, to save space, the theory will be given for the atoms of even nuclear charge alone, that is for those whose nuclei are compounds of alpha particles. As shown above the alpha particle has a weight of 4.00 and a positive charge of 2 (net charge). From three to eight of these particles will unite to form a complex nucleus, and it is evident that the weight of the nucleus must be twice its charge, that is twice the atomic number. However 9 alpha particles do not unite (at least only in minute amounts) but ten alpha particles will unite if two negative cementing electrons are used to bind on one extra alpha particle. On account of the presence of these two negative electrons, the nuclear charge is only 18, or just what it would be if 9 alpha particles *alone* had formed it. The atomic weight is thus four plus twice the atomic number. This may be put in the form of an equation.

$W = 2(N+n)$, where W is the atomic weight, N is the atomic number, and n is the number of cementing electrons in the nucleus (n is zero for light atoms), that is they are similar to the electrons which escape as beta particles from the nuclei of radio-

Digitized by Google

active atoms. Why is it that when eight alpha particles can unite without any cementing electrons, it is necessary that such cementing electrons, which always add on in pairs shall be present in the nuclei of heavier atoms. This is because alpha particles repel each other, since they are positively charged, when at a distance, but when very close together attract on account of the action of their positive and negative charges as couples, though they still repel due to their positive net charge, but when only a few, up to 8, alpha particles are united the attraction exceeds the repulsion. However with more than 8 the repulsion becomes too great for the formation of a stable nucleus. The ratio of negative to positive electrons in the alpha particles is one to two, or ½. When the positive charge in the nucleus gets too large for the formation of a stable nucleus, the nucleus may be stabilized by the addition of the helio group described above, since the ratio of negative to positive electrons in the helio group is one to one, and its introduction increases the ratio of the negative to the positive electrons in the nucleus. Thus in element 16, sulphur, the ratio of negative to positive electrons is 0.5, as it is in practically all of the lighter atoms, but by the addition of one alpha group and two cementing electrons (a helio group), this ratio is raised to 0.55, which gives the requisite stability for the existence of the argon nucleus. Then alpha particles will add on, several in direct succession, until again the increase in the positive charge on the nucleus, makes it necessary that 2 more cementing electrons be added in one step. Thus the cementing electrons increase in steps, and at each step the atomic weight increases by eight instead of by 4 as in the simple addition of alpha groups. For this reason the atomic weight increases more rapidly among the heavy than among the light atoms.

Evolution of the Atoms.

The elements have thus been found to fall into two series: first, those of even, and second, those of odd, atomic number. Now, if the theory presented for the structure of the atoms is correct, then it should be possible to find some difference between the two series with reference to their properties. Since, however, this part of the theory refers specifically to the structure of the nuclei of the atoms, and not to the arrangement of

Digitized by Google

the external or non-nuclear electrons, it is evident that this difference should not be found in those properties due to the external electrons, that is in the chemical or physical properties. On the other hand, the difference should be found in any properties inherent in the nucleus, and the only property, aside from mass and weight (from which our system has been developed), which has thus far been discovered, and which is due to the structure of the nucleus of the atom, is that of atomic stability. Thus, if an atom loses outer electrons, it does not change its atomic number, and therefore does not change to another element, but if it loses nuclear electrons, it does change its nucleus, its atomic number is changed, and the atom is said to disintegrate—that is, it changes into the atom of another element.

Our theory therefore indicates a probable general difference in stability between the even- and odd-numbered elements. A consideration of the radioactive elements indicates that those which have odd atomic numbers have either shorter periods, or else are at present unknown. Now unfortunately there is no known method of testing the stability of the elements of low atomic number, but it might seem, at first thought, that the more stable atoms should be the more abundantly formed, and to a certain extent this is undoubtedly true. If then, at the stage of evolution represented by the solar system, or by the earth, it is found that the even-numbered elements are more abundant than the odd, as seems to be the case, then it might be assumed that the even-numbered elements are on the whole the more stable. However, there is at least one other factor than stability which must be considered in this connection. The formula of the even-numbered elements has been shown to be nHe'. Now, since that for the odd-numbered elements is $nHe'+H_3'$ it is evident that if the supply of the H_3' needed by the elements was relatively small at the time of their formation, not so much material would go into this system, and this would be true whether the H_3' represents three atoms of hydrogen or one atom of meta-hydrogen (υ).

In studying the relative abundance of the elements the ideal method would be to sample one or more solar systems at the desired stage of evolution, and to make a quantitative analysis for all of the ninety-two elements of the ordinary system. Since this is evidently impossible, even in the case of the earth, it might be considered that sufficiently good data could be obtained

Digitized by Google

from the earth's crust, or the lithosphere. However, the part of the crust to which we have access is relatively so thin, and has been subjected to such far-reaching magmatic differentiation, and to such extensive solubility effects, that it seems improbable that the surface of the earth at all truly represents its composition as a whole. The meteorites, on the other hand, show much less evidence of differentiative effects, and undoubtedly represent more truly the average composition of our planetary system. At least it might seem proper to assume that the meteorites would not exhibit any special fondness for the even-numbered elements in comparison with the odd, or, vice versa, any more than the earth or the sun as a whole, at least not unless there is an important difference between these two systems of elements, which is just what it is desired to prove. A study of

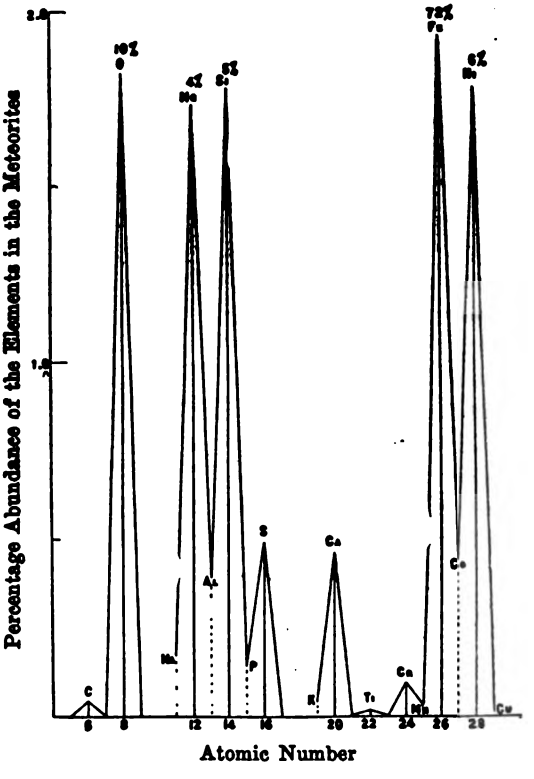


FIG. 1. The Periodic Variation in the Abundance of the Elements as the result of Atomic Evolution. The data are given for 350 stone and 10 iron meteorites, but the relations are true for meteorites in general. Note that *ten* elements of even atomic number makes up 97.59 per cent. of the meteorites, and *seven* odd-numbered elements, 2.41 per cent., or 100 per cent. in all. Elements of atomic number greater than 29 are present only in traces.

Digitized by Google

the compilations made by Farrington, by Merrill, and by other workers of analyses of meteorites, has given some very interesting results.

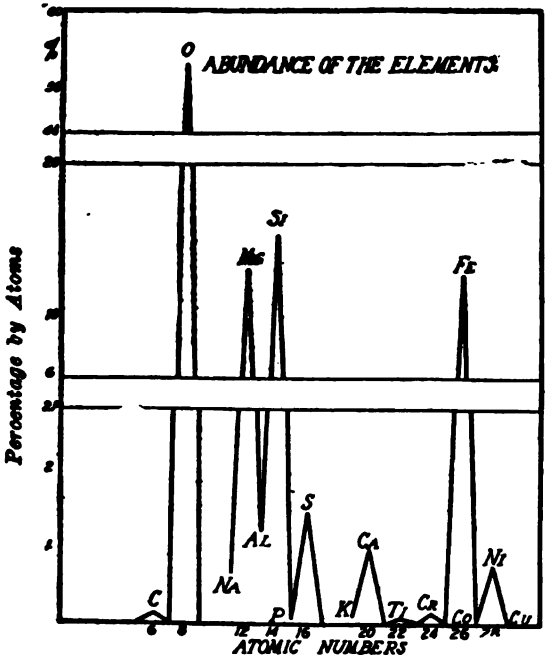


FIG. 2. The abundance of the elements in the meteorites. Every even-numbered element is more abundant than the two adjacent odd-numbered elements. (Percentage by weight Average for stone and iron meteorites.)

The results show that in either the stone or the iron meteorites the even-numbered elements are very much more abundant than the odd. Thus in the iron meteorites there are about 127 times more atoms of even atomic number than of odd, while in the stone meteorites the even-numbered elements are about 47 times more abundant. If we average the 125 stone and 318 iron meteorites given by Farrington, it is found that the weight percentage is 98.78 for the even- and 1.22 for the odd-numbered elements, or the even-numbered elements are about 81 times more abundant.

If we consider these same meteorites, 443 in all, and representing all of the different classes, it is found that the first seven elements in order of abundance are iron, oxygen, silicon, magnesium, calcium, nickel and sulphur, and *not only do all of these elements have even atomic numbers, but in addition they make up 98.6 per cent. of the material of the meteorites.*

Table IV (see Figs. 1 and 2 also) gives the average composition of these meteorites. The numbers before the symbols are

Digitized by Google

TABLE IV.

Average Composition of Meteorites Arranged According to the Periodic System.

Series	Group 1 Odd	Group 2 Even	Group 3 Odd	Group 4 Even	Group 5 Odd	Group 6 Even	Group 7 Odd	Group 8 Even	Group 8 Odd	Group 8 Even
2				6C 0.04%		8O 10.10%				
3	11Na 2.17%	12Mg 3.80%	13Al 0.39%	14Si 5.20%	15P 0.14%	16S 0.49%				
4	19K 0.04%	20Ca 0.46%		22Ti 0.01%		24Cr 0.09%	25Mn 0.03%	26Fe 72.06%	27Co 0.44%	28Ni 6.50%
	29Cu 0.01%									

the atomic numbers, and those below give the percentages of the elements. *It will be noted that the even-numbered elements are in every case more abundant than the adjacent odd-numbered elements.* The helium group elements form no chemical compounds, and are all gases, so they could not be expected to remain in large quantities in meteorites. For this reason, and also because the data are not available, the helium or zero group is omitted from the table.

From this table it will be seen that while *high percentages*, as great as 72 per cent. in one case, *are common among the even-numbered elements*, the highest percentage for any odd-numbered element is less than one per cent. (0.39 for aluminium).

If we now turn to the composition of the earth, it is found that the atoms of even atomic number are about ten times more abundant in the surface of the earth than those which are odd. Also, all of the six unknown elements except the element of atomic number 72, eka-caesium, eka-manganese 1, eka-manganese 2 (dwi-manganese), eka-iodine and eka-neodymium, have odd atomic numbers.

While the relative abundance of the elements in the lithosphere is undoubtedly much affected by differentiation, there is one group whose members are so closely similar in chemical and physical properties, that they would be much less affected in this way than any other elements. These are the rare earths. The only difficulty in this connection is that of making an accurate estimate of the relative abundance. In this the writer has been assisted by Professors C. James and C. W. Balke, but any errors in the estimate should not be attributed to them. In the table, which includes beside the rare earths a number of elements adjacent to them, the letter *c* indicates common in comparison

Digitized by Google

with the adjacent elements, and *r* represents rare. *ccc* represents a relatively very common element, etc. The comparison is only a very rough one, but it indicates that the even-numbered elements are in general more abundant than the odd-numbered ones which are adjacent.

TABLE V.

The Predominance of Even-numbered Elements Among the Rare Earths.

Atomic Number.	Abundance.	Element.	Atomic Number.	Abundance.	Element.
55	c	Caesium	63	rr	Europium
56	ccc	Barium	64	r	Gadolinium
57	c	Lanthanum	65	rrr	Terbium
58	cc	Cerium	66	r	Dysprosium
59	r	Praseodymium	67	rrr	Holmium
60	c	Neodymium	68	r	Erbium
61	rrr	Unknown	69	rr	Thulium
62	c	Samarium			

The above results may be summarized in the statement that *in the formation of the elements much more material has gone into the elements of even atomic number than into those which are odd*, either because the odd-numbered elements are the less stable, or because some constitutent essential to their formation was not sufficiently abundant, or as the result of both causes.

It is easy to see, too, that in the evolution of the elements, the elements of low atomic number and low atomic weight have been formed almost exclusively, and this indicates either that the lighter atoms are more stable than those which are heavier, or else that the lighter atoms were the first to get the material, and their stability was at least sufficient to hold it.

It is possible that the heavier atoms have been formed in larger amounts than now exist, and that their abundance has been reduced by atomic disintegration. It is of course evident that the radio-active elements are now disintegrating, but the radioactive series of elements includes only those of atomic number 81 (thallium) to 92 (uranium); and lead (82) is the end of the series as now recognized. For our purposes, however, we still call the atoms of atomic numbers 1 to 29 the lighter atoms, and from 30 to 92 the heavier atoms. The following table indicates that when defined in this way the lighter atoms are extremely more abundant. In the table the weight percentages are given, but it is evident that if these same figures were calculated to atomic percentages they would show even smaller values for the heavier elements. The table shows that although the heavy atoms have been so defined as to include more than twice

Digitized by Google

as many elements as the light atoms, their total abundance is so small as to be relatively insignificant. The data are taken from estimates by Clarke and by Farrington.

TABLE VI.

Illustrating the Large Proportion in Various Materials of the Elements of Low Atomic Numbers (1-29)

Material	Percentage of Elements with Atomic Numbers 1-29	30-92
Meteorites as a whole	99.99	0.01
Stone meteorites	99.98	0.02
Iron meteorites	100.00	0.0
Igneous rocks	99.85	0.15
Shale	99.95	0.05
Sandstone	99.95	0.05
Lithosphere	99.85	0.15

It is thus seen that *so far as the abundance of the elements is concerned, the system plays out at about element 30*, and it is of great interest to note that it is just at this point that other remarkable changes occur. For example, *up to this point nearly all of the atomic weights on the oxygen basis are very close to whole numbers.* On the other hand the elements with higher atomic numbers (28 to 92) *have atomic weights which are no closer to whole numbers than if they were wholly accidental. Also, just at this point the atomic weights cease to be those predicted by the helium-hydrogen theory* of structure presented in this paper (Table I.). This does not mean, however, that the helium-hydrogen system fails at this point, but that the deviations in the atomic weights for the elements of higher number are produced by some complicating factor. This is easily explained as due to the fact that these elements are practically all mixtures of isotopes. It is quite possible that radioactive disintegrations have proceeded downward in the system as far as iron, and that iron is the end of a disintegration series. If this were true, it would explain the great abundance of iron in the meteorites. In whatever way we may average the analyses of the materials found in meteorites or on earth, the two most striking elements from the standpoint of abundance are oxygen, the most abundant of the elements of very low atomic number (8), and iron, which has the highest atomic number (26) of any very abundant element.

The fact that the elements which have heavy atoms (atomic numbers 30 to 92, or more than two thirds of the elements) have been formed in such minute amounts would be very much more

Digitized by Google

striking to us if we lived on an earth with a perfectly uniform composition. On such an earth, formed without any segregation, it is probable that almost none of these elements would have been discovered. Quite certainly such elements as gold, silver, iodine and arsenic would not be known, and copper, lead, zinc and tin, if known at all, would be in the form of extremely small specimens.

In this connection it may be remembered that *the earth has the highest density of any of the planets.* The data given in Table V show that in the meteorites, which vary in density from about 2.5 for the lightest stone, to more than eight for the heaviest iron meteorites, *the increase in density is not brought about by an increase in the abundance of what have been defined as the heavy atoms, but only by a shift in the relative abundance of the light atoms.* Thus in the less dense stone meteorites, the average atomic percentage of oxygen, atomic weight 16, is 54.7 per cent., while that of iron, atomic weight 55.84, is 10.6 per cent. In the more dense iron meteorites, on the other hand, the percentage of oxygen is practically negligible, while that of iron has risen to 90.6 per cent.[5] A study of the densities of the elements and their compounds shows that the abundance of the elements does not seem to be related to this property. In fact the only apparent relation is to the atomic number, which indicates that the abundance relations are the results of evolution, that is of the factors involved in the formation and disintegration of the atoms.

Since the hydrogen-helium theory was first announced it has been pointed out by Norris F. Hall that both the *isotopic complexity*, and the *number of predominant radiation* of the radioactive elements show a sharp alternation with increasing atomic number, and that this alternation is strictly in accord with the general hydrogen-helium theory of atomic structure. The variation of these properties is illustrated in Figure 4 and it will be seen that the general form of these figures is the same as that of Figures 2 and 3 which represent the abundance of the elements.

Energy Changes in the Formation or Disintegration of Atoms.

When one gram of uranium disintegrates and finally changes into lead, the amount of heat liberated is about four billion

[5] For nickel, atomic weight 58.68, it is 8.5 per cent.

Digitized by Google

calories, or about five hundred thousand times the amount of heat liberated when the same weight of coal is burned. If the hydrogen which is known to us is not a mixture, then, if it could be made to react with itself to form helium, the amount of energy liberated would be twenty million times that produced by burning the same amount of coal, or one *pound* of hydrogen is in this sense equivalent to one thousand *tons* of coal, with a value

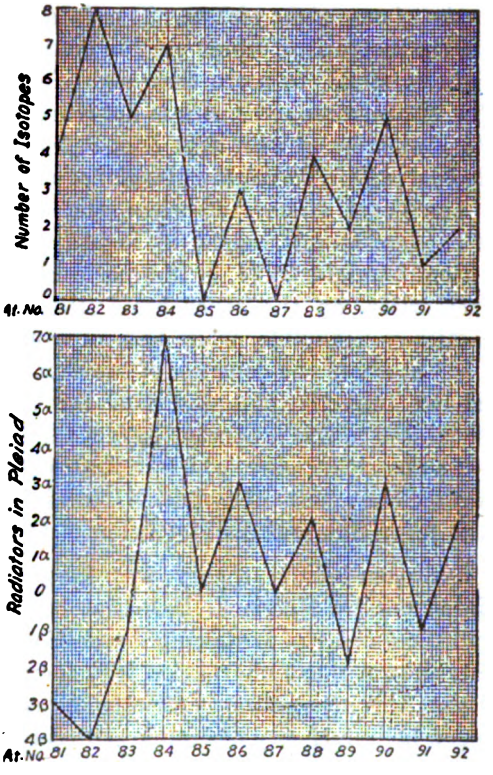


FIG. 4.

of about $10,000. The difficulty at present in the way of the utilization of these enormous amounts of energy is that the first change mentioned above takes many billion years for its completion, and no one, as yet, has any idea as to a method by which the second change may be brought about. As has been stated by Sir Oliver Lodge, the discovery of a method of unlocking these enormous stores of intra-atomic energy, will bring with it enormous possibilities, either for good or for evil.

Digitized by Google

THE STRUCTURE OF THE HELIUM AND META-HYDROGEN NUCLEI.

The material which has thus far been presented in this paper has a very solid basis in the facts upon which it is based. It may be of interest to speculate as to the structure of the helium nucleus, which is built up from four positive electrons and two negative electrons. The electromagnetic theory of Lorentz, as has been stated by Rutherford, leads to the somewhat remarkable, but easily understood result, that since the positive electron is about 1835 times *heavier* than the negative electron, the radius of the positive electron is 1835 times *smaller*. This is based on the idea that mass is proportional to energy, and the smaller a charged particle is, the greater is the energy due to its charge, since the charge repels itself.

While the more ordinary idea is that both the positive and negative electrons are spheres, they may be discs or rings, or may, of course, have some other form. The model which I would like to suggest for the helium nucleus, or alpha particle, may be made as follows: cut out a disc of thick glass or very heavy cardboard of any desired diameter, say 4 inches. Put this on a horizontal surface, and near its edge put four small discs of metal, say 1-4 inch in diameter, these four metal discs being put at the corners of a square. Above these lay a second disc of glass exactly similar to the first. Seal each glass disc to every metal disc. If it is now imagined that the metal discs are heavy, but the glass discs have almost no mass, this gives a good model for a possible structure of the helium nucleus. It will be noted that in this model the negative electrons (glass discs) do not come closely in contact, and the positive electrons are far apart, but the positive electron comes in close contact with the negative, thus giving an explanation of the loss of mass due to the approach of the positive to the negative electrons, which attract each other.

The meta-hydrogen nucleus may be assumed to have the same structure as the alpha particle, except that, since there are only three positive electrons, they are arranged at the corners of a triangle. The nucleus of the lithium atom may possibly be composed of one of each of the above particles, alpha and nu, and may be assumed to have its seven positive electrons arranged at the corners of two squares which have one corner in common, with two negative electrons above, and two below, one over, and one below each square. It is possible that the lithium nucleus and not the nu group is the lightest particle of odd positive charge. In this case the lithium nucleus would

Digitized by Google

probably have a different structure. It is of interest in this connection that while one alpha and one nu particle unite to form the nucleus of the lithium atom, two alpha particles will not unite, but three, four, five, six, seven, eight, or ten alpha particles will unite, which suggests that the nuclei of complex atoms are built up of rings or shells of alpha particles, together with any added nu or mu particles. Those who wish to study the details of this system, may refer to the *Physical Review*, February, 1920, or to any or all of the following references:

Journal of the American Chemical Society, 37, 1367–1421, 1915; 38, 186–214, 1916; 39, 856–879, 1917; 41, 970–992, 1919. *Phil. Mag.*, 30, 723–734, 1915. *Science*, N. S., 46, 419–427, 443–448, 1917. *Proc. National Academy of Sciences*, 1, 276, 1915; 2, 216–224, 1916.

THE DISINTEGRATION OF NITROGEN.

By R. W. Millar,

Division of Physical Chemistry, University of Illinois.

[Editor's Note: Great scientific interest has been aroused by a series of experiments performed by Professor Rutherford, because of their bearing on certain important scientific conceptions. If the conclusions reached are verified by later experiments, then this is the first time that one element has been changed to others by an external force. This may necessitate some fundamental changes in our elementary theories and opens vast possibilities for the transmutation of elements. The new notion concerning the law of inverse squares is likewise of great importance in physics and physical chemistry. For more complete information the reader is referred to Rutherford's article in the Philosophical Magazine, June, 1919, or the review in Science *50* 467, Nov., 1919.]

When a disc of metal is exposed to radium emanation, or niton, under certain conditions it becomes coated with a layer of solid radium C which gives off α and β particles. We are here concerned with the α particles, the velocity of which is 19,000 kilometers per second, which is sufficient to give them a range in air at atmospheric pressure of 7 centimeters.

During the greater part of this range the velocities of all the α particles are constant and equal, but in the last centimeter they lose practically all their velocity and are deflected by the molecules of air. These α particles, each with a mass of four with respect to the hydrogen atom, have an enormous kinetic energy. Rutherford calculates that one gram of matter moving with their velocity has the same kinetic energy as 10,000 tons moving at a speed of 1 kilometer per second. Their energy is so great that when a particle impinges upon a crystal of zinc sulphide a flash of light is seen. The particles will pass through thin plates of aluminum or gold until the stopping power of these plates is equivalent to that of 7 centimeters of air. Thus a thin plate of metal may be substituted for any part of the 7 centimeters of air in order to decrease the actual speed and range of the α particles.

Digitized by Google

Rutherford replaced air with hydrogen and found that the number of scintillations observed on the screen remained constant up to 19 centimeters from the source of α particles, and then fell off rapidly, becoming zero at a range of 28 centimeters. The β rays were deflected from the field by means of an electromagnet. By interposing absorption plates in order to prevent any α particles from reaching the zinc sulphide screen, Rutherford was able to determine the number of hydrogen atoms at each range. Then, by placing foils of metal in contact with the source of α particles he was able to secure α particles and to observe the number of scintillations produced by them.

Marsden had shown that hydrogen atoms could produce scintillations on a zinc sulphide screen similar to those produced by α particles. The hydrogen atoms were evidently set in rapid motion by collision with the α particles, and being lighter, were given a greater speed and consequently greater range. However, the speeds and the distribution of the swift hydrogen atoms were far different from those calculated by Rutherford on the theory that the α particles were point charges. The only method of accounting for the number and distribution of the swift hydrogen atoms was by assuming that the α particles approached within 2.4×10^{-13} centimeters of the center of the hydrogen and that at this small distance, which is less than the diameter of the electron, viz., 3.6×10^{-13}, the law of inverse squares holds.

Marsden and Rutherford found that a small number of scintillations were always observed up to 28 centimeters in air. These appeared in spite of all precautions to remove hydrogen from the materials used. Whether they are a product of the disintegration of radium C or from some other source, could not be ascertained. Their number was the same when the α particles passed through either oxygen or carbon dioxide.

When nitrogen or oxygen is used in place of hydrogen, swift atoms are observed up to a range of about 9 centimeters. It is seen that, owing to their greater mass, these atoms are given much smaller velocity than hydrogen atoms. A few hydrogen atoms of the unknown origin appear which have a range of 28 centimeters. Pure, dry nitrogen, however, gives a much greater number of swift atoms of range 28 centimeters than oxygen or carbon dioxide, or air. Air, however, gives a larger number than oxygen or carbon dioxide.

These swift atoms appear to have the same mass, charge, and

Digitized by Google

velocity as the swift hydrogen atoms obtained by the collisions of α particles with hydrogen as shown by measurements of e/m for swift atoms from the three sources: hydrogen, nitrogen, and the source or hydrogen occluded in the materials used. Furthermore, nitrogen, when bombarded by α particles, appears to be the source of hydrogen atoms. The number thus obtained is, however, comparatively small.

Rutherford has given evidence of three possibilities.

1. Radium C may radiate H atoms as well as α and β rays.
2. The law of inverse squares probably holds at distances smaller than the diameter of the electron.
3. Nitrogen may be disintegrated by α particles giving hydrogen as a product.

ILLUSTRATION OF MOLECULAR MOTION.

By J. Norman Taylor,

Washington Preparatory School, Y. M. C. A., Washington, D. C.

A proper appreciation by secondary school students of the "habits of Nature," which are expressed in abstract statements called "laws" because of their unfailing truth, is more readily brought about if concrete examples are given to illustrate their application.

For instance, it is very difficult for an immature mind to appreciate the modern theory of the composition of matter. When it is said that matter is not continuous but is of its own nature discrete, i. e., composed of unit particles known as molecules, it is difficult for the student to grasp the full meaning of this abstract statement. His idea regarding the behavior of these molecules is also a vague one. It is very hard for him to visualize the movements of particles infinitely small, contained in a transparent vessel, and themselves invisible. If he can perform an experiment which will illustrate to him how molecules move very rapidly in straight lines until they collide with each other or come into contact with the walls of the containing vessel, then he will be able to perceive that molecules are elastic. He will also be able to accept the postulate that the interstices between the molecules must of necessity be larger than the molecules themselves. Furthermore, if a student is enabled, through an appropriate illustration, to understand that when heat is applied to the system the molecules move much more rapidly, then he will be in a much better position to take up the

Digitized by Google

study of the gas laws. He will also be enabled to understand more thoroughly the kinetic theory of gases which is based upon all of these considerations.

A device illustrating the assumed behavior of molecules, and described by E. R. Stoekel in "Science," Vol. XLVIII, No. 1245, has been employed by the writer in assisting chemistry students to a better understanding of the molecular theory. It consists essentially of a hard glass tube about ten inches in length and one inch in diameter containing a pool of mercury which supports a small quantity of finely crushed material. In using this form of apparatus in the Association School laboratory it has been found that particles of cobalt glass of about twenty mesh are very satisfactory. After preparing the tube, as here indicated, it is evacuated so that a pressure of less than a millimeter obtains and is then sealed from the pump. During the subsequent demonstration the tube may be held in the hand without inconvenience but may, if desired, be clamped to a standard.

Upon the application of heat to the mercury pool and upon gradually increasing the temperature, the particles on the surface "were carried away by the evaporating mercury" and moved about in the upper part of the tube in much the same manner as gas molecules are presumed to behave.

After completion of the demonstration by the instructor each student may be allowed to verify the experiment. The use of this simple device excellently enables the student to form a clear mental picture of how the very small gas molecules are supposed to be in constant motion and how the speed of this motion is altered by changes in temperature.

POTASH DEPOSITS IN SPAIN.

Potash deposits were discovered a few years ago in the Province of Barcelona, Spain, near the villages of Suria and Cardona. They consist of irregular beds of carnallite and sylvinite interbedded with rock salt. Explorations to a depth of several hundred feet show that in the Suria district potash beds occupy an area of not less than 75 acres and occur at depths from 125 to 200 feet. The average combined thickness of the carnallite beds is estimated to be about 56 feet, and of the sylvinite about 13 feet. The Cardona upper beds are interbedded with gypsum and clay, but the lower beds contain nearly pure white salt, which is that principally mined. After the discovery of potash at Suria, these Cardona beds were searched for potash, and nearly pure sylvite was found. Estimates for the area prospected place the quantity of carnallite at 2,550,000 tons and of sylvinite at 1,150,000 tons.—[*U. S. Geological Survey.*

Digitized by Google

THE PLACE OF GENERAL SCIENCE IN THE HIGH SCHOOL.[1]

By John Calvin Hanna

State Supervisor of High Schools, Springfield, Ill.

(Appearing on the program as "General Science in the High School of Tomorrow.")

The title of the paper suggests these questions:

1. Should general science have a place in the high school?
2. Should it be a prescribed or an elective study?
3. How long a course should it be?
4. How should it be organized?
5. Where in the course should it be placed?

These questions are involved each with the others and it is difficult to answer them independently.

The answers to these, in the opinion of the writer, may be concisely expressed thus:

1. General science has a legitimate place in the high school—a place won after long experimentation.
2. It should, if offered at all, be prescribed for all students—whether in large or in small schools and whatever kind of a course is to be taken by the pupil, as well as whatever his plans are after completing a high school course.
3. The course in general science should be a full time one-year course, with at least one double time period a week given to laboratory work performed by the pupils themselves.
4. It should be organized with special reference to the pupils' degree of maturity, as a basis for further studies and as a real introduction to the whole field of natural science. It should, therefore, be organized with a sound logical foundation and conducted with due reference to the natural interest of youth in concrete illustrations of principles and familiar phenomena produced by the operation of nature's laws.
5. It should come first—before the study of special fields of natural science and before the study of applied science in vocational fields. That is, it should be taken in the ninth grade.

If in some schools it shall prove possible and wise to reorganize the work of the seventh and eighth grades in accordance with the sanest and most consistent propositions of the advocates of a junior high school,then it might be taken in the junior high school. If so, it ought to be longer than a one-year course—possibly to run through the seventh and eighth grades.

Its position, under these circumstances, might be determined at the same time and in the same way as might the position of elementary manual training.

The writer was led to these opinions on those five points first, by a vivid impression that the ordinary approach to science study in high schools was false pedagogically, as well as most unsatisfactory in its results.

That impression was made first some twenty-six years ago

[1]Read before the General Science Section of the Central Association of Science and Mathematics Teachers, held in Chicago, Nov. 29, 1919.

Digitized by Google

or more and has been confirmed by studies ever since that time. I have no doubt that a similar impression was made upon the minds of many teachers in high schools, both upon those who were teachers of botany, zoology, physiology, chemistry, physics, and physical geography, and upon other teachers as well who, like myself, were teachers in other fields, and especially also upon thoughtful administrative officers, principals, and superintendents, and also upon some college professors.

Whether the impression was developed as early as that in the minds of the masters of pedagogical theory, I do not know. So far as I have read or heard, none of them published anything on the subject until long after that.

Most of those, I believe, who began to develop those ideas were practically *forced* to it by the actual conditions which prevailed.

After the period of "natural philosophy" studied from a book only—a period and a plan which in the hands of an enthusiastic teacher had the result, no doubt, of stirring interest in science studies in the minds of many a youth; after the period next following, viz., the period of the fourteen weeks text books—books which unquestionably had their place in the progressive movement in regard to science studies, then came the period of highly differentiated and more or less perfectly developed laboratory courses in several of the subdivisions of natural science: physics, chemistry, botany, zoology (with the incidental struggle between these two and a course labeled "biology"), human physiology and the earth science study commonly labeled physical geography or physiography (sometines degenerating, or if that be too harsh a word, narrowing itself to a course in the study of erosion, pure and simple).

The specialists captured the field. Fresh from special training in the universities, burning with enthusiasm and a fierce loyalty each to his own special field, these young teachers, many of them at least—in the long and painful struggle for precedence among the special subdivisions of science study—some at least of these teachers developed into narrow and bitter partisans, so that the war between science specialists soon overshadowed the ancient and chronic war between the advocates of science studies and the advocates of the humanities—causing, no doubt, many a chuckle of sinful glee among the defenders of the humanities who, very naturally, and very foolishly, rejoiced at this division in the ranks of their opponents.

Digitized by Google

In the meantime, some actual trials were being conducted of a plan whereby not any one but all of the different fields of science study should be included—even if in brief and elementary fashion—still, should be included honestly and in good scientific spirit in an introductory course of elementary science.

This was not yet labeled "General Science." It was wrought out painfully with open mind by teachers who sought not each to glorify his own special field (for of course all of them had a special predilection for some such special field), but whose whole study and aim was to find out what kind of a course best suited the age of the pupil entering a real high school, and best prepared him for what he was to do afterwards—(first) in the later special science courses almost universally taught, (second) in taking up later such special applied courses as agriculture and household science, (third) in actual preparation for the duties of subsequent years, whether a part of those years was to be spent in college or not.

I am reciting especially the story of the Oak Park experiment, but I am confident that somewhat similar experiments were conducted in other schools in the earliest years of the present century. I am informed that President Hessler, of James Millikin University, has collected a considerable amount of material concerning this earliest pioneering, and I hope its publication may be possible in some form that will help to clear some of the problems for such a body as this.

The writer was fortunate in being one of those connected in a capacity of general supervision and encouragement with those earlier studies and experiments and the results amply justified the efforts of those faithful, modest and painstaking teachers, efforts conducted through a term of nine years with classes of 150 to 350 new students each year and with laboratories kept busy all day, but *without any printed textbook* (for none had yet been printed).

Certain conclusions were reached by these studies:

(1) Such a course is possible and is greatly needed.
(2) It must in its formation recognize intelligently the logical classification of science phenomena under the headings which label the ordinary special sciences.
(3) These lines of demarcation need not be made so conspicuous as to disturb the even tenor of the pupil's development in the scientific method of study nor his increasing recognition of the great underlying truth that nature's laws, many of them, are manifest everywhere and the phenomena which obey these laws are almost inextricably tangled.
(4) Such a course will rouse and maintain the interest of all pupils if properly presented. This is an overwhelming statement and yet is based upon a sufficient number of examples to be perfectly safe.

Digitized by Google

(5) It must include the actual performance of definite and carefully selected experiments by the pupil himself under the guidance of the teacher, with a constant training of his power to record phenomena and draw conclusions. Such a training is of value, not only in future natural science studies. It is of vital importance in all studies and applications of social sciences—in history and civics, in the political, economic and sociological problems of life, in living as a safe and helpful citizen.

(6) The practical questions incident to the putting of such a course generally into successful operation are important, such as the supply of teachers fitted for this work and the cost of equipping a special laboratory.

Some opponents of the whole movement have based their opposition on the fact that the field of natural science has become too vast for any one teacher to master it all, and that as a consequence it is folly to expect or to pretend that we can have properly fitted teachers of "general science."

This objection falls to the ground when we bear in mind that not one high school in five in this state is large enough to employ a separate teacher for each of even three or four sciences.

Not more than about one hundred high schools in Illinois have a senior class so large that even two sections in physics are formed, and only perhaps fifty or sixty high schools have a sufficient enrollment to require the formation of three physics sections—the number that would be necessary to warrant the employment of a physics teacher who teaches no other subject.

The fact is that in ninety per cent of the high schools of the state, whether any so-called general science courses are taught or not, the same teacher conducts classes in two or more sciences and does the work as well as it is done in other departments of the school—history, mathematics, language. Few, if any, high school teachers pretend to be *masters* even of one field of study, but a very large proportion of them do fairly acceptable work in more than one field, and especially in fields as nearly related as are those of the different science subdivisions.

The other practical question, the equipping of a laboratory, is easily answered. Most small high schools (and most high schools *are* small—enrolling less than 100 pupils) do very well with one laboratory room for all science classes.

Many of the smallest schools, even those with only ninth and tenth grades maintained, are now doing good, honest, helpful work with some laboratory experimentation conducted by the pupils themselves at a table in the same room where other classes are conducted—the *only* room used for all high school work in that particular school.

It would be an enlightening experience for some high school principals and teachers if they could accompany Mr. Thrasher

Digitized by Google

or myself in our visits to the recognized two year high schools of the state—schools where a total enrollment of twenty is something for the principal to point to with pride, and to see the work accomplished there in all subjects—even in general science.

Others of these schools are not so good, but there is a steady improvement. Many pupils who have had two years in such little schools are now making creditable records as eleventh and twelfth grade pupils in strong four year high schools and others still are winning out in college or university.

This presentation of the results of actual trial goes far, it seems to me, to determine the possibility and value of such a course not only, but also to furnish an answer to the fifth question appearing at the head of this paper, with the statement that experience proves that this course not only should precede all other special science studies, but should precede the domestic science and agriculture courses in the high school. Furthermore, the experiments justify the conviction that the course should be prescribed for all pupils and not allowed merely as an elective. The peculiar value of the training which it gives is needed by every boy and girl facing youth and its privileges.

In the requirements for recognized high schools in Illinois it is included that the course in general science, if taken at all, must be a year course with at least one weekly double time laboratory exercise and that it shall include a sufficient amount of the study of human physiology to satisfy the statutory requirement of forty lessons in that subject and that it shall be required of all pupils in the ninth grade. In small schools with a small enrollment in the ninth and tenth grades, respectively, making possible the uniting of those two classes in one subject, the general science may be offered in alternate years, the two classes uniting in one year in general science, and in the alternate year in ancient history or in certain other subjects exactly set forth in published circulars.

The practical question arises as to what entrance credit should be given by colleges and universities for such a course. Many colleges and universities even now allow it one full entrance unit and the tendency has been to agree to such allowance whenever university authorities have actually inspected the working of such a course in a school where it is well taught.

There is in some quarters, notably the University of Illinois, a tendency to be suspicious of the value of such a course—analogous no doubt to the long continued hesitancy of universities

Digitized by Google

to allow any entrance credit for manual training or domestic science—a conservatism based originally no doubt on sensible considerations, but seeming to some impatient young principals and superintendents a hesitancy too long protracted and unfair. These principals and superintendents have found such a course of value, have seen it produce good results and they feel that, in the words of Stephen A. Forbes uttered twenty years ago, "It is the business of the university to learn what the high schools can do and do well and then to accept that for entrance credit."

This paper is not the place for discussion of the university's policy. Let us hope that the decision to accept general science for entrance credit under proper limitations and restrictions may not be much longer delayed.

In the meantime, I have not hesitated in consultation with those school authorities where there was a strong desire to conduct courses in general science and a chafing under the fact that this would cut out one entrance credit at the university for pupils who offer it, to call their attention to the fact that any college or university requires fifteen units for admission without condition from an accredited school, and that all recognized high schools must require sixteen units for graduation. The sixteenth unit may be general science. Of course, this makes it necessary for the school to secure full unit-for-unit credit for the other subjects in its course, and this is something possible for a school really deserving the full accrediting relation.

Usually the hitch is in the English. Perhaps thirty or forty per cent of the public high schools on the university's accredited list are giving four years to English and receiving only three or three and one half units for that work.

Some of those schools, no doubt, could so strengthen their English curriculums as to conform to the university's requirement for securing four units for four years of English, and in such cases, I have, when asked for advice, given the advice, "Strengthen your English, win four units, and hold to your general science if you really want it."

There are now, or were in August 1919, in Illinois 540 recognized four-year high schools (of which 75 have probationary recognition), 94 recognized three-year high schools, and 141 recognized two-year high schools, most of these two latter groups having probationary recognition.

A careful examination of the records for 1918-19 shows that 144 of these 540 four-year high schools offer a course called

Digitized by Google

general science and most of these require it of all pupils in the ninth grade. There are also about 50 or 60 of the two-year and three-year high schools offering general science; nearly 26 per cent in all.

Nearly all of the other high schools in 1918-19 required of their pupils in the ninth grade instead of a general science course a unit composed of two half units, one of which is physiology and the other physical geography or botany or zoology or elementary civics or commercial geography.

These pupils in those schools *not* teaching general science, in a very large number of cases, are put through two half units—one of physiology and one of physical geography, and in a considerable number at least of the smaller schools where no general science is taught, this first year's work is followed by a half year each of zoology and botany.

The question of course arises whether those half units, three in a biological field and one of earth science, constitute a safer, more helpful and sounder introduction to the later activities of the youth, both in and out of school, than does the year course of general science. Even if there be objection, one might say, to these brief science courses—each of one half year—surely that objection would apply with increased force to a year unit in which the whole field of natural science is attempted to be covered.

There is the crux of the whole question. A good general science course is not an attempt to "cover," to go over, to explore the whole field of natural science, It is not a grand lightning tour; it is a bird's eye view, and as such should precede any particular toad's eye view.

It is for the purpose of enlightening the mind and rousing the interest of the pupil to the great truth that *law* runs through the natural world, and that not only in a detailed study of microtomic sections of a leaf stem or a crayfish's structure is there manifest the operation of law, but that law governs mechanics, sound, light, heat, electricity, chemical change, animal and plant life and the phenomena of geography and meteorology.

It is not necessary thoroughly to explore nor to cover all these fields in order to establsh forever in the adolescent mind this great truth.

A few carefully selected experiments in each of these fields, skillfully utilized by a careful instructor with his eye set upon the real aim to be reached, and with constant reference to the

Digitized by Google

fundamental principles thus established will accomplish the *result*, the recognition of the imperial sway of nature's law, and will rouse the interest and ambition of many a youth to further studies in some one of the special fields toward which in this preliminary survey the bird's eye has been turned.

It will, of course, serve also the other purpose, as important in the pedagogy of adolescence, the training of the mind to observe phenomena, record evidence and draw conclusions from evidence only—a training of the utmost value in preparing for citizenship—a training to be accomplished for practical purposes not only through the theorems and problems of geometry, though these are almost essential to making the fiber firm, but also through a study of law's operations in the phenomena of natural science, and indeed of the social sciences, where, of course, is shown the special application of this training to many of the problems of citizenship.

Since all youths are to be citizens, and therefore need such training, since the preliminary view is needful for the growing mind just beginning to think for itself, and since experimentation has demonstrated the possibility of doing this thing well through this medium in one year and not in less, and since more time can not be spared and, speaking practically, is not needed, it is to be concluded that general science should be taught for one year and to all pupils in the ninth grade, with the possible exception as to junior high schools referred to above.

One item in this conclusion perhaps may still be questioned: "And since more time for such a course can not be spared and speaking practically is not needed."

Why not give *two* years to this general view before taking up special sciences?

The answer is found in the stern fact that this question, and all questions of curriculum are not going to be decided by specialists, but by pupils, parents, boards of education, and by superintendents and principals, each of whom has the task of working out a plan whereby the best use of four years will be made by actual living boys and girls, the selection of sixteen units from the vast number classified as proper for use in high schools.

The general list of such units approved for recognized high schools foots up 48½, and the addition of other units actually approved and in operation in some of the larger schools would bring the number probably to sixty units, allowable in high school courses—out of which sixteen are to be selected for any individual

Digitized by Google

boy or girl. Some one may say that is an easy matter, agree upon a brief list of absolutely prescribed units, say six or eight of the total of sixteen, and make electives of all the rest.

This may work in a very few large schools, but in the overwhelming majority of our high schools the range of electives is and always must be greatly limited. No school in Illinois offers the whole range. Most schools have no electives at all or a very limited range.

An examination of the published list of 540 recognized four-year high schools shows that out of the first 287 in the alphabetical list (almost one half) and including the twenty-two large Chicago high schools, 220 of these schools have not more than ten teachers—that is, more than 76 per cent of these schools can not offer a very wide range of electives.

Furthermore, 156 of them, that is 54 per cent, have not even five teachers and half of them have only three teachers, which means practically no electives but a fixed course for all pupils.

Therefore, the elective loophole will not show the way out for pupils in more than half the four-year high schools of the state and, of course, nothing of the kind is possible in any of the three-year or two-year high schools which, in themselves, constitute more than one third of all the recognized high schools in Illinois. And these small high schools are not to be ignored, not to be despised. Whoever does so merely advertises his own ignorance. The material in them is just as good. Much of the instruction in them is good and many of our best college and university students started in such schools.

Three fourths of all high schools are "small" high schools, with an enrollment of less than one hundred. One fourth of the whole hundred thousand high school pupils in Illinois are in such small schools. The problem thus narrows itself to what is the best selection of sixteen units to be laid down for all boys and girls—omitting a few hundreds or thousands of exceptional ones in exceptional environment.

Suppose a joint high commission were charged with the duty of framing such a course, and suppose such commission to be absolutely unbiased and to have an eye single to one aim. Then suppose this commission should ask each group or section of specialists for the number and title of the minimum list of units in that particular field which, in their judgment, should be included in such a total list of sixteen units. How do you think they would come out?

Digitized by Google

The English people would insist on four units—and some think that limit is all too short.
The mathematics people will call for three units.
The history and social science section people will call for four units.
The language specialists demand four units at the very least and are aggrieved if this be cut to three or two.
The science specialist can see nothing less than four units and even then *somebody* is crowded out.
The vocational and prevocational demands will not down. Their claims run from four down to two units.
And then there are the later demands for economics, physical training the arts; and I came near forgetting the claims of the commercial branches.

Here they are—English, mathematics, ancient languages, modern languages, history and social science, natural science, vocational, commercial, artistic and physical—at least nine distinct fields, each of which includes two or more subdivisions.

How can their claims be ignored? How can any of them claim four units?

Let me go through the motions of acting as if I were that commission or had the deciding vote in its deliberations.

Only one of these can with reasonableness demand four units required of all pupils in all courses—and that is English. If we other specialists are reasonable, we are all going to vote for that list of four.

Mathematics must be satisfied with two, one each of algebra and geometry, with the content of each trimmed and readjusted to fit the modern world.

History and the social sciences must be given three units and this is little enough in view of the ghosts that have arisen lately to confront us.

As to languages, ancient and modern, I will leave them all out of the prescribed list, if I can get all the other specialists to be half as reasonable. And yet I have strong faith in the value of Latin properly taught and of the practical usefulness of a working knowledge of some of the modern languages.

There must be at least one unit of hand work for all pupils; otherwise we ignore the most outstanding fact in youthful psychology and physiology.

One unit for music and drawing, or at least one of them, if it were a possibility, is sadly needed. We need to educate for that one-third of every twenty-four hour day which is devoted to recreation—that one-third of the day within which is found all the crime and vice.

There is almost as serious a need for some universal instruction in practical accounts, and physical training must be looked

Digitized by Google

after. Suppose each of these two has a half unit; then where do we stand?

English	4 units
Mathematics	2 units
History and social science	3 units
Hand work	1 unit
The arts	1 unit
Commercial and physical	1 unit
A total of	12 units, leaving

four units for other groups. Natural science should be given two of these as prescribed units and two only, and the other two units should be free for choice on the part of the individual pupil in a school with a range of electives and for the school itself where a range of electives is impossible.

Such a distribution of units, it seems to me, would commend itself to an unprejudiced and intelligent being from another planet, making a complete study of our needs. Now, if this is fair, we are going to make a selection of two science units which *must be taken by all pupils* in all high school courses. What shall they be?

My own feeling is that the first should be what we are calling general science, organized as I have suggested, and the second should be what the pupil (or the community) calls for—but that it should be a *special science* unit thoroughly studied for a year.

The pupil should have a chance to carry through one full year's work in one special field of science after going through his preliminary year of general science.

It may be a biological unit, a unit of chemistry or of physics or of earth science—for many pupils, in my opinion, it should be a unit of advanced geography—but that is another story.

I close, not hoping to settle these great questions, but to have contributed a little to lead us who are or have been specialists to rise up high enough to see how broad is the world of education and how necessary it is to recognize the value of other wholly separate fields in the arrangement of the high school course—a work finally to be done by the administrative groups of educational experts.

Digitized by Google

TALK ON LOGARITHMS AND SLIDE RULES.[1]

By Florian Cajori,
University of California.

During July 24-27, 1914, there was held at Edinburgh, in Scotland, an international gathering of mathematicians, to celebrate the three hundredth anniversary of a great scientific event—the invention of logarithms.

Besides British men of science, there were present French, German, American, Russian, and Turkish scientists. That the celebration of an invention in mathematics should be the occasion of an international gathering seemed to indicate that the world had indeed risen far above ordinary intellectual levels and had reached a disposition to friendly intercourse and a spirit of real comity.

Little did we know what was brewing in the dark and hidden recesses of political intrigue. The only visible clouds were some minor and local social struggles. One of the meetings for the entertainment of the foreign guests was to be held in M'Ewan Hall of the University of Edinburgh,—a hall noted for its elaborate and artistic decorations. The place of meeting was finally changed to an unpretentious club house, to prevent the possibility of injury to the decorations by the militant suffragettes. The mathematical program was carried through without a disturbance of any sort. The suffragettes abstained; all foreign representatives met in friendly intercourse. The town of Edinburgh gave itself up to the celebration of the achievements of John Napier, who, next to Sir Walter Scott, was proclaimed the greatest of Scotsmen.

At the scientific meetings, papers of historical interest relating to logarithms and methods of computation were read. Mathematical instruments of all sorts and mathematical models were exhibited. It was made plain that the logarithms published by John Napier, in 1614, were not what mathematicians unfamiliar with the history of their science often think they were. Napier's logarithms were not to the base e ($= 2.718 \cdot \cdot \cdot \cdot \cdot \cdot$), nor to the base e^{-1}. In fact his logarithms do not admit of being explained on the concept of any base. If a positive number b that is larger than unity is selected as a base, then 0 must be the logarithm of 1. In Napier's logarithms this relation did not hold. His system rested on a different foundation.

[1] A talk given before the undergraduate Mathematics Club of the University of California, March 10, 1920.

Digitized by Google

In his system, 0 was the logarithm of 10^7. His tables were primarily constructed for computations involving the *sine* function in trigonometry. He took $sin90^\circ$ equal to the radius and the radius equal to 10^7. It seemed easiest to him to arrange his system so that the logarithm of $sin90^\circ$ would be zero. Hence $\log 10^7 = 0$. In his system the logarithm of a product was not equal to the sum of the logarithms of the factors, but in solving proportions, his results were theoretically accurate.

Our common logarithms, to the base 10, were agreed upon at a meeting of Henry Briggs with John Napier; Briggs had gone from London to Scotland to visit Napier. Which of the two men deserves the chief credit for adjusting logarithms to the base 10 is not known. At the congress of 1914 in Edinburgh, a Scotsman argued that the main credit is due to Napier; an Englishman argued in favor of Briggs. This divergence of opinion was probably not due to sectional bias though unfortunately, national predilection is often evident in the history of science.

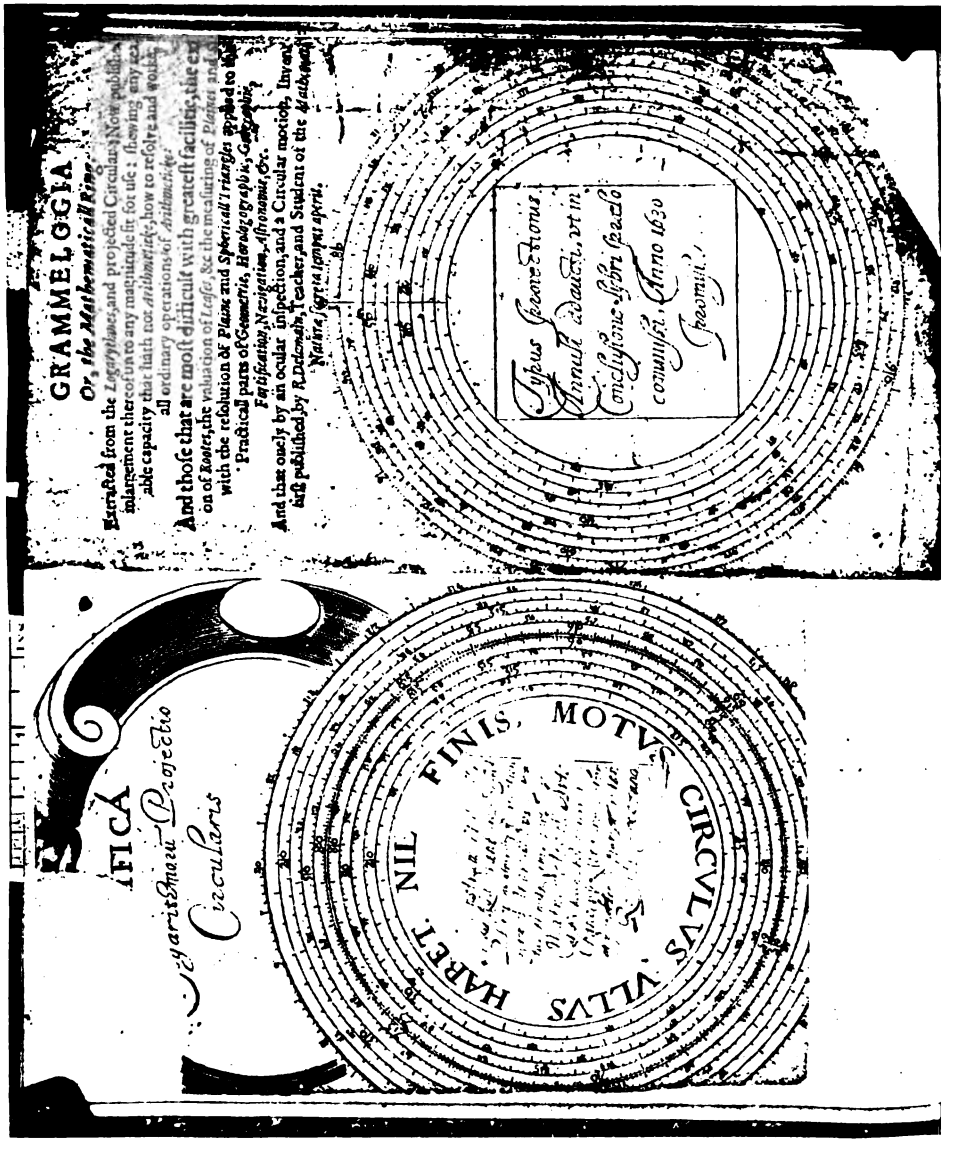
One of the mathematicians from Cambridge, Dr. J. W. L. Glaisher, was able to contribute a new historical fact on logarithms. He pointed out[2] that the natural logarithms, to the base $e(= 2.718 \cdot \cdot \cdot \cdot \cdot)$ came in earlier than was formerly supposed. They are found in a publication which appeared only four years after Napier's *Descriptio* of 1614. The second (1618) edition of Edward Wright's translation of Napier's *Descriptio* into English contains an anonymous *Appendix* describing a process of interpolation with the aid of a small table containing the logarithms of 72 sines. The latter are natural logarithms with the decimal point omitted. Thus, log 10 = 2302584. This *Appendix* which contains the earliest natural logarithms known to history is probably from the pen of the English algebraist, William Oughtred.

Seldom is a great discovery or invention the uncontested output of one mind. For the invention of the telescope, pendulum clock, and electric telegraph there are in each case several competitors. In the case of logarithms, John Napier must divide the honor of invention with Joost Bürgi, a Swiss clockmaker and mathematician. As Bürgi published his tables in 1620, six years after Napier's, the priority lies clearly with the Scotsman. So rare is Bürgi's book on logarithms that none of the British and American mathematicians attending the celebration had previously seen it. The copy exhibited in Edinburgh had been

[2] *Quarterly Journal of Pure and Applied Mathematics*, Vol. 46, 1915, p. 145.

Digitized by Google

borrowed from the library of the city of Dantzig, at that time located in Germany.


GRAMMELOGIA
Or, the Mathematicall Ring
Extracted from the Logarithmes, and projected Circular: Now published for the
enlargement thereof vnto any magnitude fit for vse: shewing
able capacity that hath not Arithmetic; how to resolve and worke
all ordinary operations of Arithmetic.
And those that are most difficult with greatest facilitie, that ex
on of Roots, the valuation of Leases, &c the measuring of Plaines and
with the resolution of Plaine and Spherical triangles applied to
Practicall parts of Geometria, Horalogiographia, Cosmographia,
Fortification, Navigation, Astronomie, &c.
And that onely by an ocular inspection, and a Circular motion. Inven
first published by R. Delamain, Teacher and Student of the Mathematic
Natura gaudet numeris.
Tybus Graecis Rationis
Annuit Deus vt in
Coelestibus sic in pueris
commissis, Anno 1630
Geometria
ARITHMETICA
Logarithmica Projectio
Circularis
FINIS. MOTVS CIRCVLARIS VILLVS HABET NIL

THE TITLE PAGE OF THE EARLIEST BOOK PUBLISHED ON THE SLIDE RULE.

There were exhibited at the University of Edinburgh, also, several designs of logarithmic slide rules. New revelations have

Digitized by Google

been made in recent years on the early history of the slide rule. Until recently altogether erroneous data were current regarding its invention. That Edmund Wingate, a writer of arithmetics, invented such an instrument is now definitely disproved. There were two rival claimants for the invention of the circular slide rule, namely, William Oughtred, whom we have mentioned as the probable author of the earliest table of natural logarithms, and one of his pupils, Richard Delamain, who was a teacher of mathematics in London. Oughtred's invention antedates Delamain's, but Delamain was the first to publish.[3] Delamain's book, the *Grammelogia or Mathematical Ring*, first appeared in London in 1630; Oughtred's *Circles of Proportion* were issued at London, in 1632, and again in 1633. As Delamain's text is the earliest printed book on the slide rule and as it has only recently been brought to the attention of modern readers, a reproduction of the two title pages will be of interest. We exhibit photograph of the title-page of a copy that is in the British Museum. The book is very rare. The present writer knows of no copies except those in the British Museum in London, the Bodleian Library at Oxford, and the Library of the University of Cambridge.

As already indicated, both Oughtred and Delamain claimed the invention of the circular slide rule. Each accused the other of having appropriated the idea. We have carefully gone over the printed statements of Oughtred and Delamain that appeared at the time, and we incline to the opinion that the two men were independent inventors. Oughtred enjoys unchallenged the honor of the invention of the rectilinear slide rule, a description of which appeared in the 1633 impression of his *Circles of Proportion*. He says that he had made models of slide rules with his own hands about eleven years before they were described in print.

[3]For details see F. Cajori, "On the History of Gunter's Scale and the Slide Rule during the 17th Century" in *University of California Publications in Mathematics*, Vol. 1, pp. 187-209, 1920.

Digitized by Google

FRESHMAN COLLEGE MATHEMATICS.

In this discussion we assume that the purpose of freshman mathematics is to give to the student the most valuable mathematical information which he is capable of receiving during that year and to develop in him the power to analyze and understand relations of quantity and space as expressed by,

1. The function.
2. The general algebraic method.
3. Applications of the principles of geometry.
4. The formula and computation.
5. Simple applications of the derivative to problems in maxima and minima, and rates.

What then shall be the content of such a course? Trigonometry and analytics use or refer to approximately one-third of the theorems in plane geometry, algebra is almost entirely independent of geometry as a basis for theory and until recently for its problem material. Thus our present course in college mathematics might be said to have as a basis, twelve topics in algebra, and sixty propositions in geometry. Of the latter not more than forty are fundamental in the theory work. Until recently applied problems in geometry, physics, chemistry, domestic science, or the evaluation of formulas were exceedingly rare, and the vitalizing facts of history and biography were entirely omitted. Theorems and topics needed for foundation work or used for discipline have been treated indiscriminately. Some of these facts are seen more clearly by referring to table VIII which shows the order of growth and development of topics in college algebras beginning with 1796 and covering a period of 122 years. The high water mark in the number of topics, pages and problems given was reached in the period from 1900 to 1910. One text written for beginners treats forty-six topics and uses 8,000 problems.

Two striking changes are seen in our recent texts. First, they omit many of those topics belonging primarily to the high-school course and place light emphasis on topics having doubtful social worth. Second, they place an increasing emphasis on the graph, compound interest, maximum and minimum, probability, evaluation of formulas, historical notes, and timing exercises.

Below we have listed topics of algebra under three heads in order to show the present tendency. First are those topics which have been dropped from the newer texts or almost so. The second classification enumerates the topics that are ap-

Digitized by Google

parently receiving less attention. The third classification shows the topics that are apparently increasing in importance and which will appear more prominently in all freshman mathematics within a few years.

I. Topics in College Algebra Which Have Largely Disappeared From the Newer College Texts. (Briefer Texts.)

1. Geometric construction of equations.
2. Harmonic progression.
3. Geometric proportion.
4. Linear equations of four or more unknowns.
5. The multinomial theorem.
6. Symmetry.
7. Euclidean method of obtaining H. C. F.
8. Comparison as a method of elimination (Simultaneous equations).
9. Indeterminate equation.
10. The problem of the couriers.
11. The problem of the lights.
12. Continued fraction.
13. Reciprocal equations.
14. Recurring series, summation of series.
15. Reversion of series, convergency of series.
16. Differential method of obtaining series.
17. Scales of notation.
18. Theory of numbers.
19. Indeterminate coefficients.
20. Cardan's solution of cubic.
21. Sturm's functions.
22. Newton's method of approximation.
23. Upper and lower limits to roots of equations.
24. Factorial binomial theorem.

II. Topics in College Algebra on Which Less Emphasis is Being Laid.

1. Involution and evolution.
2. Quadratic surds.
3. Simultaneous equations of three or more unknowns.
4. Factor theorem.
5. Topics belonging to ninth grade algebra.
6. H. C. F. and L. C. M. Sometimes omitted.
7. Powers of polynomials.
8. Progressions, except the infinite geometric series.

Digitized by Google

9. Cube root.
10. Solution of cubic, except by Horner's Method.
11. Determinants of order higher than three.
12. Binomial theorem.
13. Long, compound, and complex fractions.
14. Partial fractions.
15. Inequalities.
16. Complex numbers.

III. Topics in Freshman Mathematics Which Are Becoming More Prominent or at Least Appearing.

1. Graph.
2. Compound interest and annuities.
3. The derivative and its applications.
    a. Maximum and minimum
    b. Rates.
4. Probability.
5. Evaluation of formulas.
    a. Geometry.
    b. Physics.
    c. Mechanics.
6. Timing exercises.
7. Biography, historical notes. There seems to be a tendency to include more problems having a social interest.
8. Integration is found in some of the recent texts.

It is doubtful if any course in the curriculum can lay for the student the foundation for the solution of business or economic problems, the interpretation of natural phenomena, the study of science, engineering, statistics, or bring the student into a closer fellowship with more than one hundred of the greatest men and women of all ages together with their method of thinking than can mathematics. Let us endeavor to make it vital in the student life and give it its proper place in the development and education of men and women.

A Suggested Course in Freshman Mathematics.

An attempt is made in the following outline to separate into groups the topics that have considerable claim to treatment in the freshman year.

GROUP A includes the topics which should be given special emphasis. The committee recommends that a three-hour course should include at least all the topics of Group A.

GROUP B includes topics that should receive consideration but not quite the same emphasis or certainty of treatment as

Digitized by Google

the topics in Group A. Thus a four or five hour course should include the topics of Group B as well as those of Group A.

GROUP C includes topics that are suitable for the capacities of freshmen, and may well be included in a five-hour course. However, they should be regarded as belonging to the superstructure of the course rather than to the topics that should be mastered.

In submitting this outline we have in mind particularly the student who takes only one year of mathematics. The thought is to give him a course that will be useful in reading scientific literature, in solving problems that he is likely to meet and in giving him a notion of the value of mathematics as an idealistic subject.

Students come into our mathematics classes at a time when they are forming their ideals and we should not neglect the ideals of scientific truth as they are involved in mathematics any more than we would the ideals of literature. All of us have heard of the recent attacks upon the place of mathematics in the schools. Our best answer to these attacks lies in studying the conditions and adapting mathematics to the new conditions. In considering the changed conditions, the place of mathematics is so well expressed by R. G. Wells in his *Mankind in the Making* that we submit the following for your consideration:

"The new mathematics is a sort of supplement to language affording a means of thought about form and quantity and a means of expression, more exact, compact, and ready than ordinary language. The great body of physical science, a great deal of the essential facts of financial science, and endless social and political problems are only accessible and only thinkable to those who have had a sound training in mathematics, analysis, and the time may not be very remote when it will be understood that for complete initiation as an efficient citizen of the new great complex world-wide states that are now developing, it is necessary to be able to compute, to think in averages and maxima and minima as it is now to be able to read and write." Those words were not written by a mathematician, but by a literary man of broad interests. It may be well for us to consider whether we should not, as teachers of mathematics, give our students such appreciation of the place of mathematics in education, as is implied in the statement of Mr. Wells.

GROUP A.

I. REVIEW TOPICS IN HIGH-SCHOOL MATHEMATICS.

The review is to be made in such a way that the student is at

Digitized by Google

the same time taking a step forward. This includes:

1. Factoring, fractions, exponents, radicals, timed drills in arithmetic.
2. Plotting points and extension of number concept to include the negative. Rectangular coordinates only.
3. Linear equations.
   a. Solved by graphs, meaning of solution.
   b. Solution of two simultaneous equations, by determinants. Use of determinants in finding the area of a polygon.
4. Theorems from geometry.
   a. Right angled triangle, when one angle equals 30°, 45°, 60°.
   b. Theorems on parallel lines cut by a transversal.
   c. Theorems on congruency and similarity.
   d. Pythagorean theorem.
5. Quadratic equations in one unknown.
   a. Solution by graphs, with a discussion of the nature of the roots and meaning of a solution.
   b. Solution by the formula $x = \frac{-b \pm \sqrt{b^2-4ac}}{2a}$ with a discussion of the discriminant and the extension of the number concept to include the imaginary.
   c. Evaluation of formulas.
      (1) Falling bodies, projectiles, similar figures.

II. Trigonometric Functions of Any Angle.

1. Definitions. Sin A = a/c, Cos A = b/c.
2. Functions of angles 0°, 30°, 45°, 60°, 90°, 120°, 135°, etc.
3. Functions of $90°-x$, $180°\pm x$, $360°-x$.
4. Table of natural functions.
5. Abundance of applied problems, i.e., verbal problems.
6. Graphs of trigonometric functions.
   a. Use in electricity, wave motion, etc.

III. A Study of Straight Line Formulas in Analytics.

1. Distance between two points.
2. Mid-point of line.
3. Slope of a line, lines parallel, lines perpendicular.
4. Slope point form.
5. Slope intercept form.
6. Two point form.
7. Two intercept form.
8. Distance of a point from a line.

Digitized by Google

IV. Ratio, Proportion and Variation.
1. An abundance of applied problems in geometry, mechanics, physics, and in determining distances.

V. Trigonometric Functions of a Given Angle.
1. Fundamental relations.
$\sin x = 1/\csc x$. $\cos x = 1/\sec x$, etc.
$\sin^2 x + \cos^2 x = 1$. $1 + \tan^2 x = \sec^2 x$. $1 + \cot^2 x = \csc^2 x$.
$\tan x = \sin x/\cos x$. $\cot x = \cos x/\sin x$.
2. Identities.
3. Application to surveying, physics, navigation, etc.

VI. Simultaneous Equations, One or Both of the Second Degree. No XY Term.
1. Method of drawing graphs.
   a. Use of points.
   b. Mechanical devices. Use of compass, right triangle, focal radii, asymptotes.
2. Solution by graphs with a discussion of the number of roots, condition of tangency, imaginary intersections.
3. Solution by substitution, or when possible by determinants.
4. Careful study of circle and parabola.
5. Applications to architecture, etc.

VII. Trigonometric Functions of $(X \pm Y)$. Sine, Cosine, Tangent.
1. Development of formulas.
2. Identities.
3. Applications, angle between two lines, etc.

VIII. Binomial Theorem.
1. Proof for positive integral exponents only.

IX. Logarithms.
1. Index laws including positive, negative, and fractional exponents.
2. Use of logarithms in computations with arithmetical numbers.
3. Use of logarithms in evaluating trigonometric expressions.
4. Tables. Logarithms of numbers, logarithms of trigonometric functions.

X. Solution of Oblique Triangles.
1. Law of sines.
2. Law of cosines.
3. Area of a triangle. $\text{Area} = \frac{1}{2}bc \sin A$
$\text{Area} = \sqrt{s(s-a)(s-b)(s-c)}$.

Digitized by Google

The attention of teachers may be called to the fact that it is not absolutely necessary to include the law of tangents or the half angle formulas; in case of omission stress should be laid upon the law of cosines, and the solution of triangles by breaking them up into right triangles.

XI. Simple Introduction to Differential Calculus.

1. Rules for finding derivatives of a few simple functions.
2. Slope of lines and curves.
3. Distance, velocity, acceleration of falling bodies.
4. Maximum and minimum.
5. Rates.

This proposed brief and simple introduction of the elements of differential calculus into a freshman course is an experiment that is being tried with success in certain colleges of the state, but is still in the experimental stage so far as wide experience is concerned.

XII. History and Biography.

Appropriate historical notes should be scattered throughout the text. Recreation problems should not be omitted, especially those used to call attention to valuable mathematical principles.

1. History of trigonometry, its use today.
2. Discovery of logarithms.
3. Development of exponents.
4. Heron, Napier, Briggs, Newton, Descartes.

XIII. The above outline presupposes a rather free use of the principles of plane geometry and elementary mechanics, in the applied work. Geometric forms and surveying instruments may be used for illustrative purposes.

Group B.

I. Permutations and Combinations.

1. Applied problems.

II. Use of Formulas in Elementary Mechanics as a Better Basis for Mechanics, Physics, Science, Etc.

III. Theory of Equations.

1. Descartes rule of signs.
2. Horner's method.

IV. Further Study of Conics. *XY* Term Lacking.

1. Parabola and its applications.
2. Ellipse and its applications.
3. Hyperbola and its applications.

Digitized by Google

4. Discussion of 1, 2, and 3, with reference to bridges, buildings, eccentrics, orbits of planets, etc.

V. Simple Introduction to the Elements of Integral Calculus.

1. Areas.
2. Surfaces.
3. Volumes.
4. Inverse rate problems.

Group C.

I. Probabilities.

1. Applications to life insurance, the Mendelian theory of inheritance, etc.

II. Tangents and Normals.

1. Point form.
2. Slope form.

IIIa. Orthographic Projections.

1. Plotting of points, and lines first, second, third, and fourth angles with some application to mechanical drawing.

or IIIb. Solid Analytic Geometry.

1. Equation of a plane.
2. Equation of a straight line.
3. Equation of a quadric surface when the axes are most conveniently located.

IV. History and Biography. Suggested topics.

1. Work of early Greeks in developing conic sections.
2. Famous problems of antiquity.
3. Thales, Copernicus, Kepler, Archimedes, La Place, Euler, Vieta.

It is suggested that teachers will find the use of a limited amount of historical material of distinct value in the way of enriching the course.

E. E. Watson, Parsons College, Chairman; Ira S. Condit, Iowa State Teachers College; R. B. McClennon, Grinnell College, and H. L. Rietz, Iowa State University, Committee.

Digitized by Google

TIME, RATE AND DISTANCE PROBLEMS.

By Jos. A. Nyberg,
Hyde Park High School, Chicago.

The object of the present paper is to call attention to a few rules and methods which have been of considerable help in teaching "time, rate, and distance" problems of elementary algebra. The textbooks show the relation between d, r, and t, and some algebras advise the use of a chart containing columns for d, r, t under which are to be entered the data for A and B, for the slow and fast trains, etc. The difficulty for the pupil, as in most prose problems, is in learning where to begin his attack, and how to derive the necessary equation from the data. In the method to be explained the chart is used, and four rules are given for its use, the underlying idea being that the six spaces in the chart must be filled *in a certain order.*

In the illustration below, the small numbers in the corners indicate the order in which the data was entered.

A and B travel toward each other from points separated by 250 miles, A at a rate which exceeds B's by 8 miles an hour. If they meet in 5 hours, at what rate did each travel?

	t	r	d
A	5 ₃	$r+8$ ₂	$5(r+8)$
B	5 ₄	r ₁	$5r$

In this chart the space corresponding to the unknown element is always the first to be entered. Or, as I state it to the pupils, the first rule is:

That quantity which is asked for in the problem must be entered first.

This rule is consistent with the pupil's previous experience for he always lets x = the unknown quantity. But the letter x is avoided as it carries with it no connotation: we can forget whether it represents a distance, rate, or a time. If the problem asks: "What is B's rate?" enter r in the proper column and opposite B; if the problem says: "How far did A travel?" enter d opposite A, etc. If, as above, the question is: "What is the rate of *each*?" let r denote the rate of the slower one, although after the first weeks r may be either the smaller or greater rate.

Digitized by Google

The second rule is: *Enter next whatever data you are absolutely sure of, but do not make more than two entries on any one horizontal line.*

Thus, in the illustration above, the distance 250 can not appear in the chart as it is neither A's distance nor B's. Many problems will contain some such number, and the pupil learns to pass it by and look for some other entry. If the truth of his entry can not be questioned, then he need have no hesitancy about entering it; i.e., he need not hesitate and think "perhaps this is the number to be reserved for use in making the equation." Attention may also be called to the fact that entries usually are made by columns: the second entry is above or below the first, the fourth is in the same column as the third. Further, the latter part of the rule limiting the entries to two on a line is the more important thing to remember, as we shall see in applying the next rule:

The remaining column is always filled by using the relation $d = rt$ and never filled by using any information given in the problem.

Thus, when four entries have been made, the pupils can close the book until the remaining column has been filled. And it must be filled "from the head," as I say to the pupil, not "from the book." The teacher should vary the problems continually so that once the d column will be filled last by multiplying r and t, another time the t column found by dividing d by r, etc. No two successive problems should be the same. The pupil's work has been mostly mechanical up to this point in the problem. Here he has the opportunity to think, to exercise his reasoning abilities in deciding upon what quantities are to be multiplied or divided. Because of this opportunity and necessity, these problems are to be considered very desirable in helping to diminish the formal character of algebra.

When the six entries have been made (the first by the unknown letter, three more by the given information, the last two by means of $d = rt$) then we can always form the equation by the fourth rule:

The equation is found by relating the last two entries, together with any unused data in the problem.

In the illustration above, the number 250 has not been used; the equation is $5(r+8)+5r = 250$.

In all prose problems the equation is the most difficult part. One trouble is that from the various quantities or numbers

Digitized by Google

mentioned in the problem, the pupil must be taught to select those which form the equation. This difficulty has here been eliminated, for the pupil knows that the equation can involve only certain terms: the ones in his last column. For most prose problems no such simple rule has been found. It is a good idea to have the pupil draw heavy lines around his last two entries so that attention may be directed to them and detracted from the previous entries. The pupil who can complete the chart by these rules and then miss the equation, misses it because he overlooks some such obvious fact as that people must meet at the same time, or at the same place, or cover equal distances if they start and stop at the same places and have traveled the same road. But for the benefit of such weak pupils, it is possible to add to the four rules the following hint[1]: *If every number in the problem has been used, then most likely the last two entries should be equated; if there is a remaining used number, it is most likely equal to the sum or difference of the last two entries.* Only the weakest pupil should have his attention called to this hint for otherwise all the work will become too mechanical.

The advantages of the four rules can best be seen by comparing this method with the usual ones. Suppose the pupil writes:

$$\begin{aligned} \text{Let } r &= \text{B's rate} \\ \text{Then } r+8 &= \text{A's rate} \\ 5r &= \text{B's distance} \\ 5(r+8) &= \text{A's distance} \end{aligned}$$

Apparently this looks like a simpler method. The trouble is that the first two lines do not suggest the third. Blank paper will not stimulate thought, but an empty column for t will suggest that something should be entered in that space. Writing the first two lines in the solution above does not suggest the third and fourth lines as quickly as does the chart. Thus the main value of the chart is its suggestiveness.

A second noteworthy advantage is its adaptability to every type and variation of problem involving d, r and t. There are in general six kinds of problems: either d, r or t may be the unknown quantity, i.e., the first entry (see rule 1) may be in any one of three columns, and the other information (see rule 2) may then fall into either one of the two remaining columns. And to all these types the same method of solution can be applied.

[1]This suggestion applies to *all* problems found in the elementary texts. It is possible of course to devise problems for which it would not apply.

Digitized by Google

Even a more complicated problem leading to simultaneous quadratics can best be studied by the same rules. Consider for example the problem:

A starts from P to Q, traveling twice as fast as B, who is traveling from Q to P. After they meet, A reaches Q in two and one-half hours and B reaches P in ten hours. If the towns are three hundred miles apart, find the rate of each.

This problem requires the two following charts, the numbers in the corners showing the order of the entries.

Before meeting.

	t	r	d
A		$2r$ 2	$300-d$ 4
B		r 1	d 3

After meeting.

	t	r	d
A	$5/2$ 4	$2r$ 2	
B	10 3	r 1	

From the first chart $(300-d)/2r = d/r$.

From the second chart $5/2 \cdot 2r+10r = 300$.

If, in the second chart, the entries in the d column had been made third and fourth, and the t column had been entered last, the pupil would be led to the equations $d/2r = 5/2$ and $(300-d)/r = 10$.

Again, if in the first chart it had not occurred to the pupil to use d as one of the two unknowns, and he had entered the letter t for both A and B, his first chart would lead to the equation $2rt+rt = 300$ and his second chart to $5r+10r = 300$.

Consider next the old "army and messenger" problem: A messenger starting at the rear of an army reaches the front in a half hour. From there it takes him one-third of an hour to reach the rear. If he travels twenty miles per hour, how long was the army? The easiest solution involves calling r the rate of the messenger and R the rate of the army. Then $r-R$

Digitized by Google

represents the rate at which the messenger gains on the head of the army when moving forward, and $r+R$ is the rate at which he catches up to the rear on his return journey.

But this is the analysis of an expert. Let us see what the beginner can learn by his use of the charts. I explain to the class that the proposer of the problem could have asked just as well "At what rate was the army moving," or "Where was the van of the army when the messenger arrived at the rear?" instead of asking "How long was the army?" But in all events, any such question could be answered if we know the elements *t, r, d,* i.e., *every problem involves certain elements upon which all others depend, and knowing which, all other questions can be answered.* Here I like to sermonize a bit and explain that all problems of life should be analyzed in that way, and that even after leaving school, this attitude of analysis is the valuable element in our training; that in every situation of life we should inquire what are the fundamental elements which decide the destiny of the whole. Hence, let us prepare the charts, enter in it the elements we know and then decide on what we shall choose as our unknown element. The charts would appear thus:

	Moving forward.			Moving to the rear.		
	t	*r*	*d*	*t*	*r*	*d*
Messenger	½	20		⅓	20	
Army	½			⅓		

As we need to have four spaces filled, *the charts suggest* that we enter the letter r for the rate of the army even though the problem does not specifically call for it. This entry will make two columns complete. The d columns can then be filled, and these columns are to be used in making the equations. We must remember that these entries under d would stand for the distance the army or messenger moved during the time entered in the t column. Now in each case the distance covered by the messenger depends upon the length (l) of the army. In the first chart we conclude $\frac{1}{2} \cdot 20 = \frac{1}{2} \cdot r + l$. The second chart tells $\frac{1}{3} \cdot 20 = l - \frac{1}{3}r$.

Digitized by Google

To summarize the points involved: first, we have four definite rules for teaching beginners how to attack the elementary problems; second, problems involving simultaneous equations yield to the same mode of attack; third, it is possible by these problems and charts to teach something of analysis, and to develop toward all problems a certain attitude of mind which will be useful after the algebra has been forgotten. This is the valuable part of the subject whose presence in a curriculum teachers are frequently called upon to justify.

SOME APPLICATIONS OF THE VARIOUS FORMS OF ZERO AND UNITY.

By Professor Richard Morris,
Rutgers College, New Brunswick, N. J.

We have the symbols 0 and 1 representing zero and unity respectively. In subtraction we also know that when a quantity is subtracted from its equal, the remainder is zero. This latter expression for zero, however, very often serves as a useful device in algebraic operations when the mere symbol would be of no service.

Unity may also have different forms of representation, such as x^0, $\sin^2 a+\cos^2 a$, $\log_e e$, $(-1)(-1)$, i^4, besides many others. When any quantity is divided by itself, the quotient is unity, whether the operation be performed or indicated. And this indicated form of unity is likewise a helpful device in effecting algebraic transformations. Since a quantity may be multiplied or divided by unity without altering its value, the multiplier or divisor may be written in any one of the various forms instead of by the symbol 1.

Some examples will serve to illustrate our meaning in the use of these indicated forms:

1. In solving $ax^2+bx+c = 0$ for x, we may use the form b^2-b^2 for zero. Multiplying the equation by $4a$, we get $4a^2x^2+4abx+4ac = 0$. Evidently if b^2 is added to the terms $4a^2x^2+4abx$ there is obtained the square of $(2ax+b)$. Hence, if b^2 is both added and subtracted, that is, if we write zero as b^2-b^2, we may add it at a convenient place in the equation without destroying the equation.

The writer appreciates that the ability to find a third term to combine with two given terms in order to form a trinomial which is a perfect square is involved in this problem. But the ability to complete the square is *very* essential and should be stressed.

Digitized by Google

2. In order to factor the expression $x^4+a^2x^2+a^4$, it will be necessary to write zero in the form $a^2x^2-a^2x^2$. This is evident since $2a^2x^2$ in place of a^2x^2, changes $x^4+a^2x^2+a^4$ into the square of x^2+a^2. We then have $(x^2+a^2)^2-a^2x^2$, which is easily factored.

3. Let it be required to change $x^4+2x^3-x^2-2x-3=0$ into the form of a quadratic. We may write it $(x^4+2x^3)-(x^2+2x)-3=0$. If now zero be written in the form x^2-x^2, the equation takes the form $(x^2+x)^2-2(x^2+x)-3=0$ which is evidently in the form of a quadratic, since one parenthesis is the square of the other. In order to change it still further and remain a quadratic, put $x^2+x=y$. It then becomes $y^2-2y-3=0$.

4. Similarly, change $2x^2-4x+3\sqrt{x^2-2x+6}=15$ into the form of a quadratic. It is evident that the part $2x^2-4x$ must be built up so as to be identical with the radicand x^2-2x+6 save for a possible coefficient. Taking out the common factor 2 we get $2(x^2-2x)$. Zero in the form $6-6$ will effect the necessary transformation for the trinomial and will make a change in the constant term. Thus we will get $2(x^2-2x+6)+3\sqrt{x^2-2x+6}-12-15=0$, or $2y^2+3y-27=0$ by making $x^2-2x+6=y^2$.

5. Take this example from analytical geometry, viz., $x^2+y^2-6x-10y+9=0$ which is the equation of a circle, the problem being to find the coördinates of its center and the length of the radius. By completing the square for those terms involving x and y separately, we see that zero must have the two forms $9-9$ and $25-25$, respectively. Using these we get $x^2-6x+9-9+y^2-10y+25-25+9=0$ or $(x-3)^2+(y-5)^2=25$. The form $9-9$ is not necessary if one observes that x^2-6x+9 is one of the two perfect squares needed.

6. If r is a root of $ax^2+bx+c=0$, which means that ar^2+br+c is a form for zero, we can show that $x-r$ is a factor of $ax^2+bx+c=0$.

Taking the identity $ax^2+bx+c=ax^2+bx+c$ and subtracting zero from the right member but in the special form above we get $ax^2+bx+c=ax^2+bx+c-ar^2-br-c$ or $ax^2+bx+c=a(x^2-r^2)+b(x-r)$.

7. Take this problem from the calculus, in which it is required to put $x^2+6x+13$ in the form of the sum of two quantities, the expression in terms of x being a perfect square. Zero must be written in the form $9-9$, in which case we get $x^2+6x+9-9+13$ or $(x+3)^2+4$.

Digitized by Google

8. Put $8+4x-4x^2$ in the form of the difference of two quantities, the subtractive one being a perfect square. In this case, zero must have the form $1-1$, when we get $9-(2x-1)^2$.

9. Put x^2-6x+5 in the form of the difference of two squares. Zero must be written $9-9$, thus giving $(x-3)^2-4$.

Thus we might multiply examples to show that zero in its various forms is a useful device and of frequent application. In our judgment, the value of this should be impressed upon the pupil and he should be encouraged to be on the alert for opportunities to employ it. Surely it will mean the exercise of his ingenuity and the satisfaction in using it will impart a relish for things mathematical.

There are many problems in which unity may be introduced, written as the quotient of two equal quantities, in order to effect transformations in solving or factoring. The following examples will illustrate:

10. In the expression $3x^2+7x+5$, take out the common factor 3. It is not apparent that there is such a common factor, but if unity is written in the form $3/3$ and applied to $7x$ and 5, we get $3x^2+3\cdot 7x/3+5\cdot 3/3$ or $3(x^2+7x/3+5/3)$.

11. Let it be required to put the final form of example 10 in the form of the difference of two squares in order to factor it. In this, zero must be written $49/36-49/36$. Applying this we get, $3[x^2+7x/3+49/36-49/36+12/12\cdot 5/3]$, unity being written $12/12$. This condenses to $3[(x+7/6)^2+11/36]$. Again unity may take the form $(-1)(-1)$, and for one of these factors i^2 may be substituted. This gives $3[(x+7/6)^2-i^2 11/36]$ whose factors are $3[x+7/6+i\sqrt{11}/6]\cdot[x+7/6-i\sqrt{11}/6]$.

12. Express ax^2+bx+c as the difference of two squares. Write unity as a/a and apply it to bx and c. Taking out the common factor a and writing zero as $b^2/4a^2-b^2/4a^2$, we get $a[x^2+bx/a+b^2/4a^2-b^2/4a^2+c/a]$ or $a[(x+b/2a)^2-b^2-4ac/4a^2]$ whose factors are $a(x+b/2a-(\sqrt{b^2-4ac})/2a)\,(x+b/2a+\sqrt{b^2-4ac}/2a)$.

13. Take the interesting problem to show that in the division of fractions, multiplication is substituted for division by inverting the terms of the divisor.

Take $\dfrac{a/b}{c/d}$ as the fraction. In this, unity must take the form

Digitized by Google

d/c
of ——. When the pupil has reached division of fractions, he
d/c
will have had practice in cancellation and will have had the definition of the reciprocal of a number, both of which ideas are involved in this problem. Using the above form of unity, we get
$a/b \quad d/c$
——×—— or $a/b \times d/c$ by cancellation.
$c/d \quad d/c$

14. In order to change $\sqrt{7/5}$ into a mixed surd, unity must have the form $5/5$ or $7/7$. Thus we have $\sqrt{7\cdot5/5\cdot5}$ or $\sqrt{7\cdot7/5\cdot7}$ which become $1/5.\sqrt{35}$ or $7/\sqrt{35}$.

15. Rationalize the denominator of $(5+\sqrt{3})/(5-\sqrt{3})$. A knowledge of conjugate quantities is essential to see that unity must be written $(5+\sqrt{3})/(5+\sqrt{3}.)$

16. Transform the binomial $(8+12x)^{\frac{1}{2}}$ into a form with unity for the first term. In order to take out the common factor 8, unity must be written $2/2$, $4/4$, or $8/8$. Applying the last form we get $(8+8/8\cdot12x)^{\frac{1}{2}}$ or $4(1+3x/2)^{\frac{1}{2}}$.

17. Let it be required to express the coefficient of the middle term of $(x+y)^{28}$ in the form of factorial quantities. This coefficient is $28\cdot27\cdot\cdot\cdot\cdot\cdot.15/\underline{|14}$, whence it is evident that unity must be written $\underline{|14}/\underline{|14}$. Applying this to the coefficient we get $\underline{|28}/\underline{|14}\ \underline{|14}$.

18. Show that $\sqrt{(1-\cos x)/(1+\cos x)} = (1-\cos x)/\sin x$. If the pupil is ready with his trigonometric formulae, he will see at once that unity must have the form $(1-\cos x)/(1-\cos x)$, and when this is applied to the radicand, we get $\sqrt{(1-\cos x)^2/(1-\cos^2 x)}$ or $(1-\cos x)/\sin^2 x$.

19. Change the following fractions to similar fractions, $a/(x+y), b/(x-y), c/(x^2-y^2)$. A knowledge of the lowest common denominator would suggest that unity in the first fraction must have the form $(x-y)/(x-y)$ and in the second fraction it must be $(x+y)/(x+y)$. In orderto change the sign of a fraction, unity must be written $-1/-1$.

20 As a final problem, let the coefficients of $ax^4+bx^3+cx^2+dx+e = 0$ be integers. In order that this may be put in the form of a quadratic, we must have $8a^3d = 4abc-b^3$.

Taking out the common factor a, we have $a[x^4+(b/a)x^3+(c/a)x^2+(d/a)x+e/a] = 0$, and building up

Digitized by Google

a trinomial perfect square, using $x^4+(b/a)x^3$ as part of the trinomial, we get

$a[x^4+(b/a)x^3+(b^2/4a^2)x^2-b^2x^2/4a^2+cx^2/a+(d/a)x+e/a] = 0$. Writing unity in the forms, $4a/4a$ and $(4ac-b^2)/4a^2 \cdot 4a^2/(4ac-b^2)$, and multiplying the terms cx^2/a and ax/a by these respectively, we get,

$a[x^4+(b/a)x^3+b^2x^2/4a^2+4acx^2/4a^2-b^2x^2/4a^2+$
$4ac-b^2/4a^2 \cdot 4a^2/4ac-b^2 \cdot (d/a)x+e/a] = 0$ or
$a[(x^2+bx/2a)^2+(4ac-b^2)/4a^2(x^2+4adx/4ac-b^2)+e/a] = 0$.

Hence this will take the quadratic form only when $4ad/(4ac-b^2) = b/2a$ or if $8a^2d = 4abc-b^3$.

These problems suffice to exhibit the wide range to which the various forms of unity and zero may be applied, and the constant effort on the part of the pupil to discover opportunities for their application will mean much to him in his mathematical career.

ATOMIC THEORY IN BASEBALL TERMS.

By Dr. Irving Langmuir.

According to our present views, all forms of matter are built up of atoms, but we no longer regard these atoms as indivisible nor even as simple structures. If a lump of ordinary matter the size of a baseball could be magnified to the size of the earth, the atoms in it would then have become about the size of baseballs. In other words, an atom is about as big compared to a baseball as the baseball is when compared to the earth. The atoms are constructed of particles of positive and negative electricity arranged in a very open structure. All the positive electricity is concentrated into a very small particle, called the nucleus, located at the center of the atom. The negative electricity exists in the form of electrons which arrange themselves in space about the nucleus. The size of the electrons and nucleus is small compared with that of the atom itself. Thus if we imagine an atom magnified until it has a diameter of one mile, the electrons would be about five feet in diameter while the nucleus at the center would be only the size of a walnut.

The electrons in different kinds of atoms are alike but there are as many different kinds of nuclei as there are chemical elements, that is, about 92 in all. These differ from one another only in the amount of positive electricity they contain. Thus for the simplest element, hydrogen, the nucleus has a unit positive charge which is able to neutralize the charge of a single electron. A hydrogen atom then consists merely of the nucleus and a single electron. The next element, helium, has a nucleus with a double positive charge and the atom thus contains two electrons. In a similar way we find that the atoms of carbon have six electrons, while oxygen has eight, aluminum, thirteen, sulfur, sixteen, iron, twenty-six, copper, twenty-nine, silver, forty-seven, gold, seventy-nine, lead, eighty-two, and radium, eighty-eight electrons.

These electrons do not revolve around the nucleus the way the earth revolves around the sun, but they are arranged in three dimensions in a series of layers or concentric shells surrounding the nucleus. The electrons are probably not stationary but each revolves in its own orbit

Digitized by Google

about a certain equilibrium position. However, as we do not yet know much about these orbits we can speak of the positions of the electrons in the atoms as though the electrons were located in these equilibrium positions.

The first two electrons in any atom form the first shell about the nucleus, that is, two electrons are much closer to the nucleus than any of the others. In atoms with more electrons the next eight electrons form the second layer; then comes another layer of eight. If there are still more electrons these arrange themselves in a layer of eighteen followed by a second layer of eighteen and finally there may be an outside layer of thirty-two electrons. It is the successive formation of these various layers which causes the similar or recurring properties among the chemical elements which underlie the Periodic Table of the elements that is of such fundamental importance in chemistry.

The eight electrons in the second and third layers are arranged in a symmetrical way like the arrangement of the eight corners of a cube. This stable group of eight electrons is called the Octet. The chemical properties of the elements result from the tendency of the individual atoms to take up or give up electrons in order to form these octets. That is, the atoms strive to take certain stable configurations characterized by geometrical symmetry. They accomplish this in some cases by exchanging electrons with each other, while in other cases the atoms share pairs of electrons with each other—a sort of cooperative plan. The pairs of electrons thus constitute the chemical bonds between atoms which play such a prominent part in chemistry.

This theory of atomic structure and chemical combination not only explains an enormous number of chemical laws which have been obtained by experiment, but it leads to important extensions and in some cases to modifications of these laws, while in other cases it has led to new relationships and has made it possible to predict correctly the properties of certain substances before these properties have been determined by experiment.

TEACHERS SUFFER MOST.

Among those employes who suffer most acutely have been the teachers in our schools. Their situation in many parts of the country has become deplorable. Thousands of them, trained in their profession, with a high and honorable pride in it, have been literally forced to leave it, and to resign what had been their hope, not of wealth, but of loyal service in building the foundation of knowledge and character upon which our national strength must rest.

In consequence there is everywhere a shortage of teachers. An inquiry made by the Bureau of Education showed that in January, 1920, more than 18,000 teachers' positions in the public schools of the country were then vacant because the teachers to fill them could not be had. Over 42,000 positions are filled, in order that they may be filled at all, by teachers whose qualifications are below the minimum standard of requirement in the several states. It is the estimate of the Commissioner of Education that more than 300,000 of the 650,000 school teachers of the country are today "below any reasonable minimum standard of qualifications."

Many of those who remain in our schools receive less pay than common laborers, despite the long years of preparation for their profession that they have undertaken. This situation is a national menace. It is useless to talk of Americanization and of the diminution of illiteracy and other national educational problems, unless it is faced at once.—[Report of the Industrial Conference, called by the President.

Digitized by Google

CLASSIFICATION OF SCHOOL SUBJECTS BASED ON EDUCATIONAL FUNCTION AND VALUE.

By Lyman C. Wooster.

State Normal School, Emporia, Kansas.

Pearson, Thorndike and many others have investigated the influence of heredity in determining what we are mentally and physically, and have found that more than one-half of our mental and physical characteristics, probably three-fourths, come to us from our ancestors through heredity. The remaining one-fourth or more we get through home training, by contact with our environment and through education in the schools.

This fourth, though small, is very important, for it determines the sphere of our activities, equips us with a knowledge of the more important discoveries of the race and furnishes us with the latest and best methods of gathering and storing information. The schools have greatly increased their usefulness in recent years by teaching the boys and girls the scientific or inductive method of Bacon and by abandoning an overemphasis of the deductive method of the school men of the Dark Ages.

As teachers now give less exclusive attention to form and content and more attention to function and use it becomes necessary to shift the classification of subjects taught in the high schools to the later basis. The following classification, based on function and use, is offered by the writer for criticism and suggestion.

1. Mechanistic.—These subjects have for their chief purpose the teaching of habits of skill, either of mind or body, and of storing the memory with the useful wisdom of the race, all resulting eventually in conserving the energy of the body, including the brain, by making many of its activities automatic. The school subjects that naturally go here are spelling, typewriting, penmanship, the tables in arithmetic, traditional farming, all subjects taught so as to give skill without conscious thought in the various trades, most laboratory work, and botany, zoology and paleontology, taught chiefly for the ready identification of specimens.

2. Vocational.—These subjects prepare for those professions and occupations which always require skill and thought power for their successful prosecution. All the biological and physical sciences can be taught so as to go here. The new sciences such as agriculture, home economics, commerce and manual training are now taught for thought as well as skill. Constructive and

Digitized by Google

informational English and some portions of arithmetic are fundamental in all the professions and occupations.

3. Avocational.—These subjects are intended to give breadth of knowledge and prepare a better citizenship. All school subjects have a more or less socializing effect, but the subjects which follow are specially adapted to this field: History, civics (well taught), political economy, sociology, English literature and all the sciences studied chiefly for information are avocational.

4. Cultural.—This much abused term was originally made to include merely the social graces. It meant music, painting, poetry, dancing, rhetoric, oratory, and grace of bearing and ease of conversation in social gatherings for people of wealth. People of leisure sought in all fields for material with which to entertain. Those who travel must know several of the foreign languages; hence French, German and Spanish were studied for convenience and as an accomplishment. The term cultural is used here in its original signification.

5. Specialistic.—Many years ago it was believed that the mind could be educated in high schools and colleges by causing it to master any subject, the less interesting and useful the better, and then that the new powers could be used in the easy conquest of the remaining subjects of the curriculum. So thoroughly convinced were the teachers of Latin and Greek of the truth of this theory that some of them inscribed above their classroom doors this warning, "Let nothing useful enter here." (—D'Ooge.)

The subjects that may be listed in this fifth group are—pure science, pure mathematics, Latin and Greek, and the deductive type of philosophy. It is now generally admitted by educators, that science for its own sake, higher mathematics, Latin and Greek literatures and deductive philosophy can be studied with profit only by specialists in universities. These experts in science, mathematics, the classics and in philosophy are mature in their mental powers and are capable of abstracting themselves from the world in which they live and confining their interests to a limited world in which they are the only inhabitants. This was illustrated by the German who spent a lifetime studying the Greek verb, and regretted when death came that he had not confined his studies to the dative case of the noun.

The specialist in science dares all, spends all, gives up all for his beloved botany, zoology, geology, physics or chemistry. The mathematician easily drifts into astronomy where he can

Digitized by Google

spend months and even years on a single problem. The philosopher is supremely happy when he can mount the cumulus clouds of his imagination and drift about in the realms of the absolute.

It is evident that classifications based on functions are not so rigid as those based on structure. People possessing the same general anatomy may function in widely different spheres of activity. In the above classification, botany and zoology, for example, may be taught as mechanistic subjects, when emphasis is placed on skill in the identification of plants and animals. Indeed, this was the only purpose in studying botany and zoology till within the past few years. Now, function and use are emphasized, as well as skill, and these subjects become vocational. Or, they may be so taught as to widen one's knowledge of his environment and to enable the pupil to readily indentify the important plants and animals as he sees them, and these subjects become avocational.

Cultured civilized man has always admired the beauty of flowers, and no social occasion is complete without floral decorations, and every yard must contain flowering plants. The painter has found in animal life abundant material for his canvas and the poet has sung some of his most delightful songs in praise of birds and insects.

This that is true of botany and zoology is more or less true of the other school subjects. They are not well taught, according to the modern educator, unless they serve to prepare the boys and girls for personal, social and civic usefulness and to enjoy all that is true and beautiful in their environments. Subjects which do not thus help to round out the lives of our young people should be dropped from our courses of study.

As to the specialistic group, the old idea that subjects should be mastered for discipline, even though they do not contribute to social efficiency, is productive of much misspent time in the schools. It has been demonstrated by Thorndike and many others that training acquired in mastering any subject can not be transferred and used in the mastery of another and different subject. Thus training acquired in mastering Latin and Greek can not be used in mastering algebra and geometry and the reverse. A small transfer of training is possible, however, when two subjects have identical elements. The identical element may be one of substance, as in mathematics and physics; it may be one of process, as in laboratory work in chemistry and zoology;

Digitized by Google

or it may be one of aim, as in all written work when the teacher makes neatness a quality of prime importance in all examination and notebook work. This last is especially effective when various emotions are aroused by a promise of rewards and punishments. In all these transfers the pupil must be made conscious that the element is identical in the two subjects or there is no transfer.

Akin to this practice of making boys and girls take traditional subjects chiefly for discipline is the one which requires the student to take pure science, pure mathematics and the classics in their entirety and for their own sake when he has no direct use for more than a very small portion of these subjects. The needs of the student are certainly paramount to the needs of the subjects, and must be observed more fully in constructing courses of study or there will be open rebellion on the part of our young people. In saying this, there is no thought of excluding specialistic subjects from the course of study of any college or university student who is making a general preparation to meet the diverse conditions of his environment. The highest success in any field of human activity is possible only when the student makes such preparation; but the educator says that that must be his object, with plenty of time in which to execute it.

TEST FOR COLOR BLINDNESS.

By Maud S. Stuart,

Faribault, Minn.

I have read in the March number of School Science and Mathematics that Mr. Turton of the Bowen High School, Chicago, gave a report at the association, on "Testing a Class for Color Blindness." For the last four years I have been paying special attention to training my pupils in physics and chemistry and paying more attention to the distinction of colors. We have found only one student who seemed to be color blind. I use the spectrum colored papers, which I purchase from Thomas Charles & Co., Chicago, buying the large sheets and each student makes his own charts, mounting 2×1 in. pieces of each of the eighteen colors—one of normal strength with two tints and two shades of each. I have a much larger chart on the wall, which I have made for reference. Then my pupils gather colored pictures, and mount them, with small pieces of paper, also mounted, showing the colors of inks used in printing the pictures. We do some work too, in finding the names of colors of samples of cloth. This year, I have purchased the Standard Color Chart of America from the Textile Color Card Association of U. S., New York City, a simplified list of about 120 colored ribbons, with names, and numbers, indicating the composition of the colors and the depth of color.

I think the majority of our young people are not color blind but they have not been trained thoroughly enough in noticing the various colors about them.

Digitized by Google

PROBLEM DEPARTMENT.

Conducted by J. A. Nyberg,
Hyde Park High School, Chicago.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. If you have any suggestion to make, mail it to him. Address all communications to J. A. Nyberg, 1044 E. Marquette Road, Chicago.

SOLUTION OF PROBLEMS.

646. *Proposed by A. Pelletier, Montreal, Can.*

Find the remainder of the division of 6^{592} by 11.

I. *Solution by N. Barotz, New York City.*

Investigation seems to show that when 6^{10n}, 6^{10n+1}, 6^{10n+2}, ... are divided by 11, the remainders will be 1, 6, 3, 7, 9, 10, 5, 8, 4, 2 and will repeat in this order. Hence $6^{592}/11$ gives a remainder 3.

II. *Solution by M. G. Schucker, Pittsburgh, Pa.*

$6^{592} = 36^{296} = (33+3)^{296} = 11N_1+3^{296}$
$3^{296} = 81^{74} = (77+4)^{74} = 11N_2+4^{74}$
$4^{74} = 16^{37} = (11+5)^{37} = 11N_3+5^{37}$
$5^{37} = 5 \cdot 5^{36} = 5(22+3)^{18} = 11N_4+5 \cdot 3^{18}$
$5 \cdot 3^{18} = 5 \cdot 9 \cdot 81^4 = 11N_5+5 \cdot 9 \cdot 4^4 = 11N_6+11 \cdot 1047+3$

III. *Solution by the Proposer.*

By Fermat's Theorem, $6^{10} =$ (multiple of 11) $+1$
Then $6^{592} = (6^{10})^{59} \times 6^2 =$ (multiple of $11+1$) $\times 36$
$=$ (multiple of $11+1$)(multiple of $11+3$)
$=$ (multiple of 11) $+3$.

Also solved by Eugene M. Berry, Iowa City, Iowa, Harold G. Donovan, senior at Concord High School, N. H., Jas. H. Packham, Collegiate Institute, Owen Sound, Michael Goldberg, student at South Philadelphia High School, Pa.

647. *Proposed by Walter R. Warne, State College, Pa.*

$S_1, S_2, S_3, \cdots S_p$ are the sums of p arithmetical progressions each continued to n terms, the first terms are 1, 2, 3, ... p, respectively, and the common differences 1, 3, 5, . . . $2p-1$. Prove that $S_1+S_2+S_3+ \cdots +S_p = np(np+1)/2$.

I. *Solution by Harold G. Donovan, senior at Concord High School, N. H.*

The sum of the first series in $(n^2+n)/2$, of the second series is $1/3(3n^2+n)$, of the pth is $[(2p-1)n^2+n]/2$. Regarding these sums as the terms of a series for which the difference is n^2,

$S_1+S_2+ \cdots S_p = p[1/2(n^2+n)+1/2(2p-1)n^2+1/2n]/2$
$= np(np+1)/2$.

II. *Solution by Nelson L. Roray, Metuchen, N. J.*

$S_1 = 1+2+ \cdots = [2+(n-1)]n/2$
$S_2 = 3+8+ \cdots = [6+5(n-1)]n/2$
$S_p = p+(2p-1)+ \cdots = [2p+(n-1)(2p-1)]n/2$
$S_1+S_2+ \cdots S_p = [2+4+ \cdots 2p+$
$(n-1)(1+3+5 \cdots 2p-1)]n/2$
$= [(2+2p)p/2+(n-1)(1+2p-1)p/2]n/2 = np(np+1)/2$.

Also solved by N. Barotz, A. Pelletier, R. T. McGregor, Elk Grove, Calif., Jas. H. Packham, Michael Goldberg, and the Proposer.

648. *Proposed by J. W. Lyle, Hartwell High School, Cincinnati, O.*

In the right dihedral angle formed by a floor and a wall is built a rectangular coal bin four feet high which extends three feet from the wall. What are the possible positions of a ladder eleven feet long that will touch the wall, the bin and the floor at the same time?

Solution by Walter R. Warne.

Let x = distance from A, the foot of the ladder, to the front foot of the

Digitized by Google

bin, and y = distance on wall from the back top of the bin, B, to the top of the ladder. Then AB = 11, $xy = 12$, $(x+3)^2+(y+4)^2 = 121$, or $x^4+6x^3-96x^2+96x+144 = 0$. By Sturm's Theorem, there are only two positive real roots, and consequently only two positions of the ladder. Horner's Method of Approximation gives $x_1 = 2.2008_1+$, $x_2 = 6.99\cdots$ Or, by Descartes' Rule of Signs there are not more than two positive real roots, and not more than two negative real roots. Also, $f(2) = +$, $f(3) = -$, $f(6) = -$, $f(7) = +$.

649. *Proposed by Walter R. Warne.*

If the inscribed circle of the triangle ABC passes through the center of the circumscribed circle, then

$$\cos A+\cos B+\cos C = \sqrt{2}.$$

I. *Solution by Jas. H. Packham.*

$\cos A+\cos B+\cos C = 1+4\sin A/2\sin B/2\sin C/2 = 1+r/R$. If I is the in-center and S the circum-center, $IS^2 = R^2-2Rr$. But $IS = r$. Hence $r^2 = R^2-2Rr$, or $2r^2 = (R-r)^2$, or $\sqrt{2} = R/r-1$. Then $R/r = 1+\sqrt{2}$, $r/R = \sqrt{2}-1$; $r/R+1 = \sqrt{2}$. Hence $\cos A+\cos B+\cos C = \sqrt{2}$.

II. *Comment by the Proposer.*

Obviously, the proposition is true for isosceles right triangles, and untrue for a $60°-30°$ right triangle or an equilateral triangle. The natural query would be: Is the theorem true for isosceles non-right triangles?

III. *Comment by the Editor.*

To answer the above query, put A = B, C = 180−2A, then $\cos A+\cos A+\cos 180-A) = \sqrt{2}$ or $2\cos^2 A-2\cos A+\sqrt{2}-1 = 0$; then $\cos A = \sqrt{2}/2$ or $(\sqrt{2}-1)/\sqrt{2}$. The first solution makes A = 45°, and the second solution will satisfy only if $\cos A+\cos B-\cos C = \sqrt{2}$. Hence, if the triangle is isosceles, it must also be a right triangle, and the hypotenuse is then a diameter of the circumscribed circle. The problem should now be put: given a circle passing through the center of a larger circle, and entirely inside the larger circle. Construct triangles for which the two circles will be the inscribed and circumscribed circles.

Also solved by A. Pelletier, N. L. Roray, and the Proposer.

650. *Proposed by Norman Anning, Orono, Me.*

Two hunters start from the same camp. A goes one mile east and then one mile N 18°E. B goes one mile N 30°E. and then one mile N 54°E. Find the distance and direction of B from A.

Solution by N. Barotz, New York City.

A goes east $1+\sin 18° = 1.30902$ mi.

B goes east $\sin 30°+\sin 54° = 1.30902$ mi.

A goes north $\cos 18° = .95106$ mi.

B goes north $\cos 30°+\cos 54° = 1.45382$ mi.

Hence B will be .50276 mi. directly north of A.

Comment by the Editor.

The solution above suggests that $\sin 30°+\sin 54° = \sin 18°+\sin 90°$, which ought to be derivable by trigonometry without tables.

Also solved by H. G. Donovan, R. T. McGregor, A. Pelletier, M. Goldberg.

LATE SOLUTIONS.

638. W. R. Warne, M. G. Schucker, Pittsburgh, Pa.
641. M. Goldberg.
643. N. Barotz, M. G. Schucker.
644. N. Barotz, M. Goldberg, M. G. Schucker.
645. M. G. Schucker.

PROBLEMS FOR SOLUTION.

661. *Proposed by Jas. H. Packham, Collegiate Institute, Owen Sound.*

Given an $\angle ABC$, a point Q on BC, and a point P between the sides of the angle. Construct an isosceles triangle, having its vertex on AB, its base on BC, one extremity of the base at Q, and the side opposite Q passing through P.

662. *Proposed by J. L. Riley, Stephenville, Texas.*

If a, b, c, d are the sides, and $\triangle$ the area, of a quadrilateral inscribed in a circle of radius R, prove that

Digitized by Google

$16R^2\triangle^2 = (ab+cd)(bc+da)(ca+db)$.

663. *Proposed by A. Pelletier, Montreal, Canada.*

Prove that the product of four consecutive numbers can not be a perfect square.

664. *Proposed by N. P. Pandya, Amreli, Kathiawad, India.*

Three equal chords (length l) of a circle form, when produced both ways, a triangle ABC. Express the sides of the triangle in terms of its angles and l. Hence find under what circumstances the sides would be in geometrical progression.

665. *Proposed by W. R. Warne, State College, Pa.*

Solve $\cos(ax) \cdot \cos(bx) = \cos(a+c)x \cdot \cos(b+c)x$.

SCIENCE QUESTIONS.

Conducted by Franklin T. Jones.

The Warner & Swasey Company, Cleveland, Ohio.

Readers are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, 10109 Wilbur Ave., Cleveland, Ohio.

ACKNOWLEDGMENTS.

Contributions not elsewhere mentioned have been received from:

Manual Training and Model High School, Fargo, N. Dak. (The contributor did not give his name.)

A. Haven Smith and class, Riverside Junior College, Riverside, Calif.

C. Harvey Waite, Gary, Ind.

Robt. W. Boreman, Georgia School of Technology, Atlanta, Georgia.

Rolland E. Klug, Bourbon, Ind.

QUESTIONS AND PROBLEMS FOR SOLUTION.

Please send in solutions of problems numbered 340, 341, 342, 343, 344, 345 in the list of questions that follows.

In the booklet from which these questions were taken there was a total of eighteen examination papers in British History, English, French, Italian, German, Latin, Greek, and Mathematics—no science whatever except this single examination in dynamics. How would our students make out with an examination of this sort? Please note, however, that success in such an examination can only be possible as result of *thorough instruction on a limited field.*

SCOTTISH UNIVERSITIES ENTRANCE BOARD PRELIMINARY EXAMINATIONS.

Dynamics.

Wednesday, 17th September, 1919, 3 to 6 p. m.

A Candidate may obtain FULL *marks by doing about two-thirds of this paper.*

Marks will not be awarded to answers where the work is not shown.

N. B.—*Candidates must write on their books the number of the table at which they sit.*

1. What is the difference between uniform velocity and average velocity? Find the angle between two equal component velocities if their resultant is equal to either of them. Compare the velocities of the extremities of the hour, minute, and second hands of a watch, their lengths being 0.6, 0.81, and 0.32 inches respectively.

2. A body, starting with a velocity (V) of 20 ft. per sec., moves for 6 secs. with an acceleration (ϵ) of 5 ft. per sec. per sec. Draw a graph showing relation between velocity of body at any instant and the time;

Digitized by Google

and prove that the area of the figure contained by the graph, the axes of coordinates, and any ordinate represents the distance travelled in a certain time. From your figure deduce the formula

$$s = Vt + \tfrac{1}{2}at^2.$$

3. State, without proof, how to find, both as regards magnitude and direction, the resultant of (i) two non-parallel coplanar forces, (ii) two parallel unequal forces acting in the same direction, (iii) two parallel unequal forces acting in opposite directions.

340. A uniform beam ABC, 24 feet long, which weighs 2 cwt. and supports two loads, each weighing 1 cwt., rests in a horizontal position on two posts, one at the centre B of the beam and the other at a distance of 10 feet from A. If one of the loads is 2 feet from A, find the distance from A of the other load when the thrust on the post at B is zero.

4. Explain, with two illustrative examples, what is meant by saying that a body has momentum. Find the ratio of the momenta of two bodies A and B in the following case: The mass of A is 1 cwt., and it moves at the rate of 30 miles per hour; the mass of B is 21 oz., and it moves at the rate of 2816 ft. per sec.

5. What is the centre of gravity of a body? Show that, if a body be freely suspended from a point O, its centre of gravity will be in the vertical line through O in the position of rest.

341. A uniform one-foot rod is broken into two parts of 5 and 7 inches, which are then placed so as to form the letter T, the longer portion being vertical; find the position of its centre of gravity.

6. Explain what is meant by (i) Work, (ii) Energy, (iii) Power; and state the units in terms of which each is measured, when the pound, the foot and the second are the units of force, length and time respectively.

342. A square shaft, of side 6 feet, is to be sunk to a depth of 60 feet in a uniform material of specific gravity 2.5. How long will a man take to do this, working with a windlass, if he does 70,000 ft.-lbs. of work daily, supposing the windlass to work without friction? [A cubic foot of water weighs 1000 oz.]

7. Define the terms: Kinetic friction, limiting friction, and coefficient of friction. Two inclined planes of equal length, the one rough and the other smooth, are tilted at angles θ and ϕ respectively, so that a body takes the same time in sliding down either. Find the coefficient of friction of the rough plane.

8. Enunciate Newton's Third Law of Motion, and give an illustration of its principle.

343. A pile, weighing half a ton, is driven ¼ inch into the ground by the blow of a hammer weighing 2 tons descending from the height of 4 feet. Find (i) the velocity of the hammer just before striking the pile, (ii) the velocity of the pile and hammer just after the blow, (iii) the average resistance of the ground.

9. Explain what is meant by "the centre of pressure" of a plane area immersed in water. If the area is a rectangle with one side in the surface of the water, where is the centre of pressure?

344. A tank with a rectangular bottom and vertical walls stands on a horizontal floor and is divided into two compartments by a vertical partition at right angles to its length. The width of the tank is 12 feet and the depth of the water in one compartment is 9 feet and in the other 6 feet. Find the magnitude and the line of action of the resultant thrust on the partition.

10. Two exactly similar straight glass tubes are fitted up as mercury barometers with their unsealed ends each resting in a bowl of mercury. Into the one is introduced a small quantity of air, and into the other a small iron ball whose diameter is less than the bore of the tube. Describe exactly and explain what will happen in each tube. If the pressure, volume, and Centigrade temperature of a gas change from a, b, c to d, e, f respectively, form an equation showing how these various quantities are related.

Digitized by Google

11. What is the Principle of Archimedes? Describe how it is applied to determine the specific gravity of a liquid.

345. A cylindrical diving-bell, 7 feet in height and 4 feet in diameter, is sunk in water till its top is 80 feet below the surface; if the height of the water barometer is 34 feet find the height to which the water has risen in the bell.

WHY not try the Panama Canal problem with your best class? The results will be interesting.

SOLUTIONS AND ANSWERS.

317. *Proposed by J. C. Packard, Brookline, Mass.*

An automobile, weighing with load 1,000 lbs., while running at the rate of 5 miles an hour collides with a telegraph pole. The fender is crushed in about 2 inches. How heavy a blow did the auto deliver?

[Query: Is this the piledriver problem in another form?—EDITOR.]

Solution by K. L. Pohlman, Cleveland, Ohio.

Before the machine is brought to rest it will have performed $1000 \times 7.3^2/2 \times 32.2 = 827.3$ ft. lbs. of work and as this energy is expended in a distance of 1-6 ft., the average force with which the machine strikes the pole equals, $827.3 \div \frac{1}{6} = 4963.8$ lb.

323. *Proposed by J. C. Packard, Brookline, Mass.*

What is the horse power required to drive an automobile weighing 2,000 lbs. up an 8% grade at the rate of 30 miles per hour?

Solution by H. W. Corzine, Cleveland, Ohio.

$$\text{Horse power} = \frac{\text{Ft. lbs. per minute moved vertically}}{33{,}000}$$

$$= \frac{2000 \times (30 \times 5280/60) \sin A}{33000} \quad \text{but } A = \tan^{-1}\frac{8}{100} = 40\text{—}35^{1}$$

$$= \frac{2000 \times 2640 \times .07991}{33000}$$

$$= 12.78 \text{ Ans.}$$

REPORT OF THE WINTER MEETING.

The regular semiannual meeting of the Southern California Science and Mathematics Association was held in the auditorium of the Central Intermediate School, Los Angeles, on Thursday, December 18, 1919, at 1:30 p. m., President E. E. Chandler presiding.

The minutes of the previous meeting held at Venice, May 17, 1919, were read and approved. The treasurer's report was read, approved by the nominating committee, and accepted by the association.

Mr. Fisk, chairman of the nominating committee, explaining that the present officers had been elected at the last meeting and thus had served but a half year, recommended that they be reelected, and made his report as follows: For president, Mr. E. E. Chandler, of Occidental College; for vice president, Miss Olive Kelso, of Pasadena High School; and for secretary-treasurer, Mr. N. D. Knupp, of Santa Monica High School. The report was approved and the secretary instructed to cast the unanimous ballot of the association for the officers named. They were declared elected by the chairman.

Under the head of new business, Mr. Fluckey, of Lincoln High School, Los Angeles, presented the following resolution:

"Whereas the Great War has emphasized the need of simplifying and standardizing computation and measurement, and

Digitized by Google

"Whereas the sharpening of trade competition in Europe and in South America makes imperative the use of measurements with which these foreign purchasers are familiar, and

"Whereas it is well-known that the system of weights and measures in common use in this country is cumbersome, difficult to learn, and wasteful of time and energy, and

"Whereas the metric system by act of Congress was made the standard for this nation many years ago, but has gained its way but slowly against the prejudice of those unfamiliar with it, be it

"Resolved, That we, the Southern California Science and Mathematics Association, do hereby urge the immediate passage of bills by our state and national legislatures which will hasten the general adoption of this system;

"That we propose as one means to secure this desired end that all construction, bids and supplies of public property after July 1, 1922, be required by law to be in metric units;

"That copies of these resolutions be sent to our state and national representatives, and to the other Science and Mathematics Associations of the United States, and

"That we hereby pledge ourselves as an association and as individuals to the further prosecution of this cause."

Upon motion duly made and seconded the resolution was adopted.

The lecturer of the day, Professor Joel H. Hilderbrand, was then introduced and gave a very interesting and valuable talk on the subject "Some Phases of the Teaching of Chemistry." He discussed first the spirit and characteristics of science in general, and then explained ways of securing and holding interest, and methods of teaching the subject of chemistry.

There being no further business, the general meeting adjourned to reassemble by sections for the election of officers and section programs which were carried out according to the printed program attached.

N. D. KNUPP, *Secretary.*

BOOKS RECEIVED.

The Carnegie Foundation for the Advancement of Teaching, Fourteenth Annual Report of President and Treasurer. 148 pages. 19×25.5 cm. Paper. 1919. 576 Fifth Ave., New York City.

Everyday Chemistry, by Alfred Vivian, Ohio State University. 560 pages. 13×19 cm. Cloth. 1920. American Book Company, Chicago.

Physiography, by Rollin D. Salisbury, University of Chicago. Third Edition. Pages xv+676. 14.5×21.5 cm. Cloth. 1920. Henry Holt and Company, New York City.

Armenia and the Armenians, from the earliest times until the Great War (1914), by Kevork Aslan, translated from the French by Pierre Crabiles. Pages xxix+138, 13.5×19.5 cm. Cloth. 1920. The Macmillan Company, New York City.

Zoology, text book, for colleges and universities, by T. D. A. Cockerell, University of Colorado. Pages XII+558. 14.5×21 cm. Cloth. 1920. $3. World Publishing Co., Yonkers-on-the-Hudson, New York.

Applied Arithmetic, Books II and III, by N. J. Lennis, University of Montana, and Frances Jenkins, University of Cincinnati. Pages IX+294 and IX+340. 13×19.5 cm. Cloth. 1920. Lippincott Publishing Co., Philadelphia.

Household Arithmetic, by Katherine F. Ball, University of Minnesota, and Miriam E. West, Girls' Vocational High School, Indianapolis. Pages 271. 14×20.5 cm. Cloth. 1920. P. B. Lippincott Publishing Co., Philadelphia.

Digitized by Google

From the Department of the Interior, Bureau of Education, Washington, D. C., the following bulletins:

Number 70, Schools and Classes for Feeble Minded and Sub-Normal Children.

Number 3, Private, High Schools and Academies.

Number 45, A Credited Report of Schools of North Central Association.

Number 77, Americanization.

Number 62, Extension work.

Number 80, Teaching English to the Foreigners.

Number 6, The Child and the Kindergarten.

BOOK REVIEWS.

Analytic Geometry, by Maria M. Roberts, Professor of Mathematics in Iowa State College, and Julia T. Colpitts, Associate Professor of Mathematics in Iowa State College. Pages x+245. 13×19 cm. 1918. John Wiley & Sons, Inc., New York.

The material of the usual course in analytic geometry is presented in this book with emphasis placed on those portions in which experience has shown the student of calculus to be most frequently deficient. Polar coordinates receive more than the usual attention, and transcendental and parametric equations receive due attention. The large number of exercises gives an opportunity of considerable choice on the part of the instructor. The well-drawn diagrams will prove of much use to the student.

H. E. C.

Fundamentals of High School Mathematics, by Harold O. Rugg, Columbia University, and John R. Clark, Department of Mathematics, Chicago Normal College. Pages xv+368. 14×19 cm. Price, $1.60. 1919. World Book Company, Yonkers-on-Hudson, N. Y.

The preparation of very few textbooks in mathematics has been based on such long continued and scientific study of the way in which children learn and the kind of mathematics that will prove of social worth to them as the authors of this book have made. As they have come to the conclusion that children do their thinking in detailed word-symbols this book is planned to make the transition from thinking in detailed word symbols to that in algebraic symbols so gradually as to keep, step by step, just ahead of the pupils' mental advance. The exposition of the text develops so gradually that the average pupil can read it and work the problems with little aid from the teacher.

The subject matter selected on two principles—social worth and thinking value—includes the use of the letters to represent numbers; simple equations; construction and evaluation of formulas; the finding of unknown distances by means of (1) scale drawing, (2) the principles of similar triangles, (3) the use of the properties of the right triangle (including sine, cosine, tangent); and the preparation and use of statistical tables and graphs. The selection of material for this course is quite in agreement with the recommendations of the National Committee on Mathematical Requirements.

Among the outstanding features of this book are: the careful explanations and development of new processes; the wise omission of formal material; the excellent presentation of word-problems; the unique organization of special products and factoring; the timed practice-exercises for developing skill in essential processes; and the emphasis upon the notion of relationship between variable quantities. Every teacher or school administrator who is interested in improving the educational value of the first-year high school mathematics course should examine this textbook.

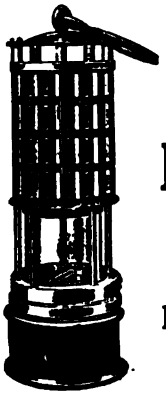
H. E. C.

Digitized by Google

A COMPLETE LINE OF

APPARATUS AND SUPPLIES

FOR



AGRICULTURE, BIOLOGY BOTANY, CHEMISTRY, PHYSICS, ZOOLOGY

Is listed in a New Catalog. Send for your copy now. Ask for Catalog S-20.

Get our quotations on your next list of requirements

E.W.A. ROWLES CO.

·MANUFACTURERS·
SCHOOL FURNITURE AND SUPPLIES
2345-51 SO. LA SALLE ST.
CHICAGO. ILL.

Everyday Chemistry, by Alfred Vivian, Dean of the College of Agriculture of the Ohio State University. Pages, 560. 13x19 cm. 1920. American Book Co.

Progressive educators are generally agreed that the studies of the high school should be organized in terms of modern life as found in the pupil's daily activities rather than organized as a logically arranged subject, particularly if the latter arrangement does not give the pupil a real insight into the purposes and values of the subject.

This viewpoint is not only desirable but necessary in order to get modern high school pupils to rub up against the educational grindstone. It is more than motivation. It is learning naturally with the need of knowledge being actually felt before the information is given.

Chemistry teachers will welcome Vivian's Chemistry since it turns the instruction of the subject in the direction of the above viewpoint. It omits some of the "classics" of chemistry to make room for the more practical. This is particularly true for the first half of the book, the treatment of metals and their compounds being excised most. This latter point is just as well for the cyclopedic listing of compounds of metals in the average text of the past was almost valueless. The atomic theory has only incidental treatment. It would be more appreciated by pupils if the main assumptions were deduced from facts rather than given in a dogmatic way. If the atomic theory is given any space it should have enough to make the mechanics of equation writing a better understood process. The author seems to use H or H_2 for hydrogen gas at will without reference to the facts of the case.

The last three-fifths of the book has a direct bearing on the chemistry of organic substances, a much larger treatment than is usually accorded this division of the subject. This is due to the author's desire to make the book useful for those schools that wish to take advantage of the provisions of the Smith-Hughes enactment for vocational instruction in Domestic Science and Agriculture. In this respect the book will give better satisfaction than any other.

Digitized by Google

of each chapter, and they are interspersed with questions to test the pupil's mastery of the information given in the text part. Some such method is necessary to direct the pupil's mental effort. This plan should succeed admirably if the pupil is held to account for his effort by satisfactory answers to the questions. It is another question regarding how much training the pupil will get from reading experimental data, when he can read so much easier from the text by turning back a few pages. The full value of individual experimental work can not be realized if a text is at hand to do the thinking and reasoning for the pupil. For this reason the laboratory directions must needs be separate from the text. Unless full value is realized the time and expense of individual laboratory work can not be justified. Vivian's Chemistry will contribute most to the advancement of chemical knowledge by helping teachers and pupils see the chemistry of life rather than the chemistry of books. H. R. S.

SOME INTERESTING FACTS CONCERNING THE RELATIONS BETWEEN THE THREE SIDES OF A RIGHT TRIANGLE.

By ROBERT R. KNOWLES,

Industrial Arts High School, Sterling, Colo.

In the past, the writer has often wished for some method by which problems in the solution of the sides of a right triangle by the Pythagorean Theorem could be assigned to different members of a class without the instructor having to waste time in checking the problems by working out each individual case. He has therefore hit upon the following plan which is original as far as he knows.

If we assume the identity,

$$k^4+2k^2+1 = k^4+2k^2+1,$$

by arranging and collecting we have

$$k^4-2k^2+1+4k^2 = k^4+2k^2+1,$$
$$(k^2-1)^2+(2k)^2 = (k^2+1)^2.$$

If then we take a triangle with k^2-1, $2k$, and k^2+1 as sides, we have by the Pythagorean Theorem, a right triangle because the sum of the squares of two of the sides equals the square of the remaining side. This may be carried out with a number of identities as shown in the table below.

Identity.	Sides.		
	a	b	c
$k^4+2k^2+1 = k^4+2k^2+1$	(k^2-1)	$(2k)$	(k^2+1)
$k^4+8k^2+16 = k^4+8k^2+16$	(k^2-4)	$(4k)$	(k^2+4)
$k^4+18k^2+81 = k^4+18k^2+81$	(k^2-9)	$6k$	(k^2+9)
$k^4+32k^2+256 = k^4+32k^2+256$	(k^2-16)	$8k$	(k^2+16)

These sides may be written

a	b	c
k^2-1^2	$2\cdot1k$	k^2+1^2
k^2-2^2	$2\cdot2k$	k^2+2^2
k^2-3^2	$2\cdot3k$	k^2+3^2
k^2-4^2	$2\cdot4k$	k^2+4^2
k^2-r^2	$2\cdot rk$	k^2+r^2

From an examination of this table it becomes apparent that the sides follow some definite law which is as follows:

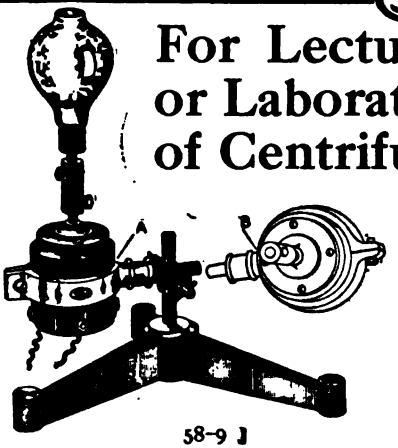
If any two values for k and r be selected, a right triangle may always be formed by substituting in the following k^2-r^2, one side, $2kr$ other side and k^2+r^2 hypotenuse, for $(k^2-r^2)^2+(2kr)^2 = (k^2+r^2)^2$ provided k is larger than r.

For example let $k = 7$ and $r = 4$. Substituting in the values in the formulae for sides we have $49-16$ or 33, $2\times7\times4$ or 56 and $49+16$ or 65 and squaring out we have $33^2+56^2 = 65^2$

or $1089+3136 = 4225$.

Since k^2-r^2 is one side and $2kr$ is the other, the area of the triangle may be found by multiplying them together and dividing by two, obtaining for the area of the triangle $kr(k^2-r^2)$.

Digitized by Google



58-9 J

For Lecture Demonstration, or Laboratory Application, of Centrifugal Force . . . . .

You Need This Waverley Electric—
A Whirling Machine and Centrifuge Combined.

As a whirling machine the Waverley-Electric takes a Centrifugal Globe (as illustrated), or Double Hoops, Centrifugal Balls, and other accessories.

A Centrifuge Head converts the Waverley-Electric into a powerful centrifuge that may be used with efficacy for the analysis of milk, urine, blood, or other liquids.

The specially designed, ball-bearing motor is mounted and balanced to operate in vertical or horizontal position. Consequently its general utility includes the rotation of Savart's Wheels, Siren Discs, Newton's Color Discs and the like.

The Waverley-Electric Specifications

Support—Standard Tripod.
Yoke—Cast Aluminum.
Housing—Enameled Iron.
Motor—6,000 R. P. M.
Mica Insulation. Self-Adjusting Brushes.
Ball-Bearing Shaft.
Current—D. C., A. C., or Dry Cells.
Chuck—Universal.

58-9 The Waverley-Electric, including Support, Yoke, Motor and Chuck.....$19.00
58-9a Waverley Centrifuge Head, four-arm.. 3.75

Cambridge Botanical Supply Company
LABORATORY EQUIPMENT—ALL SCIENCES
1-9 Lexington Street 1884-1920 Waverley, Mass.

EDUCATION

40th year Sept. 1919. $3 a year. Sample 20c.
120 Boylston St., Boston, Mass.
"AS NECESSARY TO A TEACHER AS A MEDICAL JOURNAL TO A PHYSICIAN"

The above formulae provide for an infinite number of right triangles which the instructor can make up almost instantly and yet have the values for his sides known to himself before the problem is given.

One more interesting fact is noticeable. If $k = 2r$ the sides are in the ratio 3, 4, and 5. This is also the case where $k = 3r$. From there on the ratios vary for if $k = mr$, substituting in the formulae for the sides, we have $(m^2r^2 - r^2)$, $(2mr^2)$ and $(m^2r^2 + r^2)$. Taking out a common factor of r^2, we have for the three sides, $r^2(m^2-1)$, $r^2(2m)$, and $r^2(m^2+1)$ and the ratios are therefore m^2-1, $2m$ and m^2+1.

When m is 1	ratios are	0, 2, 2 (impossible)
2		3, 4, 5
3		8, 6, 10 or 4, 3, 5
4		16, 8, 17
5		24, 10, 26
6		35, 12, 37

and so on, the triangles becoming closer and closer to isosceles right triangles but having the two longer sides always differing by 2.

[Note by Math. Ed.: For a full discussion of this problem see the following numbers of this journal: November, 1910; April, 1911; April, 1913.]

Digitized by Google

GOVERNMENT REPORT ON THE SUNSET-MIDWAY OIL DISTRICT OF CALIFORNIA.

The immense growth in the world demand for petroleum and its products is taxing to the uttermost the capacity of the known oil fields and stimulating the search for new ones. The study of the producing fields is being carried on more and more intensively, not only to learn what contributions may be expected from such new fields as may be found but to maintain the declining production of the old fields and to squeeze the last profitable drop from them.

The work of finding petroleum and of producing it is becoming less and less "a gamble" and more and more an exact science. Geologic work is not only essential to the discovery of new fields but can be profitably continued to direct exploration and production in old fields. For the lack of geologic work different producing beds reached by different wells have been confused during the early life of a field, and the possible sources of water trouble have been overlooked.

Men who might have been millionaires have been made practically penniless because they abandoned a well too soon through ignorance or misconception of the true number and position of the oil-bearing beds, and companies well on the road to success have suffered serious reverses by useless expenditure incurred in drilling wells where there was practically no chance of striking oil, and by deepening holes that had already passed through all the possible oil-bearing beds. Entire fields have been abandoned, or almost abandoned, only to be reopened when applied science or random drilling revealed the existence of oil sands below the old "pay." Other fields have been lost through water trouble due to carelessness, lack of experience, or ignorance of the true source of the trouble and how to prevent it.—[*U. S. Geological Survey.*

DR. IRVING LANGMUIR RECEIVES NICHOLS MEDAL.

The William H. Nichols Gold Medal presented annually by the New York Section for the best original paper printed in the publications of the American Chemical Society was conferred for 1919 last evening (Friday, March 5) upon Dr. Irving Langmuir, a noted physical chemist connected with the General Electric Company, of Schenectady, New York, for his paper entitled, "The Arrangement of Electrons in Atoms and Molecules." The subject is of far reaching importance on account of the belief in scientific circles that the world is on the verge of discovering methods for utilizing the force pent up in the atom along the lines suggested by Sir Oliver Lodge, Sir Ernest Rutherford and other distinguished physicists. The conferring of the award took place in Rumford Hall, 50 East 41st Street, at the monthly meeting of the New York Section, the speech of presentation being made by Dr. Nichols, former president of the Society and donor of the medal. After the acceptance Dr. Langmuir delivered an address entitled, "Octek Theory of Valence."

The jury in reporting its decision stated that, in view of the award of the same honor to Dr. Langmuir in 1915, it took special pleasure in thus again giving recognition to his continued valuable services to chemical science.

Dr. Langmuir was born in Brooklyn in 1881. He was graduated as a metallurgical engineer from Columbia University in 1903 and three years later received his doctor's degree from the University of Gottingen. He was for several years an instructor in chemistry in the Stevens Institute of Technology, Hoboken. He has done much research work in gas reactions, water vapors, iron pipe corrosions, and more recently in the application of tungsten to the manufacture of electric lamps.

Digitized by Google

Vital-Modern-Scholarly

. SCHORLING AND REEVE'S

GENERAL MATHEMATICS

This book offers students the mathematical help that the average man will need most.

The authors have presented a considerable amount of material, giving the teacher a wealth of desirable options.

GINN AND COMPANY

2301 PRAIRIE AVENUE, CHICAGO, ILLINOIS

COAL MINING IN ALASKA.

The Matanuska coal field, in Alaska, is just now of special interest because it is tributary to the Government railroad and because of the coal-mining developments carried on by the Department of the Interior through the Alaskan Engineering Commission. The United States Geological Survey, of the Department of the Interior, has therefore issued, in its Bulletin 712-E, a paper by Theodore Chapin entitled "Mining Developments in the Matanuska Coal Field." Mr. Chapin is in charge of the branch office of the Geological Survey at Anchorage, Alaska, and is actively cooperating with the Alaskan Engineering Commission in the development of these mines. His report is part of the Geological Survey's regular annual account of mining in Alaska and is based on several weeks' field work done at different times in the summer and fall of 1918 and on an intimate knowledge of the mining and prospecting that were done in that year. The report includes a brief description of the general geology of the coal field, a statement of the results of tests and analyses of the coal, a detailed account of the mining and prospecting done in 1918, and descriptions of the geologic features at the mines and maps of areas near them, as well as many sections showing the geologic relations of the coal beds. The report is supplemental to the more general accounts of the geology and coal of the Matanuska Valley that have already been published by the Geological Survey.

The same bulletin contains also a short paper by Mr. Chapin entitled "Lode Developments in the Willow Creek District," which is the customary brief annual statement of the developments of the year of the gold lode mines of that district.

Bulletin 712-E can be obtained free of charge from the Director of the Geological Survey at Washington, D. C.

Digitized by Google

DIRECTORY OF SCIENCE AND MATHEMATICS SOCIETIES.

Under this heading are published in the March, June, and October issues of this Journal the names and officers of such societies as furnish us this information. We ask members to keep us informed as to any change in the officiary of their society. This is extremely valuable information to all progressive teachers. Is your Society listed here? Names are dropped when they become one year old.

AMERICAN GEOGRAPHICAL SOCIETY OF NEW YORK.

President, John Greenough; *Vice-Presidents*, Paul Tuckerman and James B. Ford; *Foreign Corresponding Secretary*, William Libbey; *Domestic Corresponding Secretary*, Archibald D. Russell; *Recording Secretary*, Hamilton Fish Kean; *Treasurer*, Henry Parish; *Director and Editor*, Isaiah Bowman, Ph.D.—1220.

AMERICAN PHYSICAL SOCIETY.

President, J. S. Ames, Johns Hopkins University, Baltimore, Md.; *Vice-President*, Theodore Lyman, Harvard University, Cambridge. Mass.; *Secretary*, D. C. Miller, Case School of Applied Science, Cleveland, Ohio; *Treasurer*, G. B. Pegram, Columbia University, New York City; *Editor*, F. Bedell, Cornell University, Ithaca, N. Y.; *Local Secretary for the Pacific Coast*, E. P. Lewis, University of California, Berkeley, Cal. *The Council of the Society consists of the President, Vice-President, Secretary, Treasurer. Managing Editor, all living Past Presidents and eight elected members as follows: Past Presidents:* A. A. Michelson, A. G. Webster, Carl Barus. E. L. Nichols, Henry Crew, W. F. Magie, Ernest Merritt, R. A. Millikan, H. A. Bumstead; *Elected Members:* Max Mason, G. O. Squier, H. A. Wilson, A. L. Day, G. F. Hull, G. K. Burgess, J. C. McLennan, F. B. Jewett; *Editor*, Frederick Bedell, Ithaca, N. Y.—220.

AMERICAN PHYSIOLOGICAL SOCIETY.

President, Prof. Frederick S. Lee, Columbia University, New York; *Secretary*, Prof. Charles W. Greene, University of Missouri, Columbia, Mo.; Next annual meeting place, Johns Hopkins Medical School—419.

AMERICAN SOCIETY OF NATURALISTS.

President, Dr. Jacques Loeb, Rockefeller Institute for Medical Research, New York City; *Vice-President*, Prof. Bradley M. Davis, University of Michigan, Ann Arbor; *Secretary*, Prof. A. Franklin Shull, University of Michigan, Ann Arbor; *Treasurer*, Dr. J. Arthur Harris, Carnegie Institution for Experimental Evolution, Cold Spring Harbor, Long Island, N. Y.—220.

AMERICAN SOCIETY OF ZOOLOGISTS.

President, Gilman A. Drew, Marine Biological Laboratory, Woods Hole, Mass.; *Vice-President*, Caswell Grave, Washington University, St. Louis, Mo.; *Secretary-Treasurer*, W. C. Allee, Lake Forest College, Lake Forest, Ill.—220.

ASSOCIATION OF AMERICAN GEOGRAPHERS.

President, Charles R. Dryer; *First Vice-President*, Dr. Herbert E. Gregory; *Second Vice-President*, Dr. Isaiah Bowman; *Secretary*, Dr. Oliver L. Fassig; *Treasurer*, Francois E. Matthes.—1219.

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS.

President, Wilmon Newell, Gainesville, Fla.; *First Vice-President*, H. A. Gossard, Wooster, Ohio; *Second Vice-President*, E. M. Ehrhorn, Honolulu, H. T.; *Third Vice-President*, J. G. Sanders, Harrisburg, Pa.; *Fourth Vice-President*, F. B. Paddock, Ames, Iowa; *Secretary*, S. F. Burgess, Melrose Highlands, Mass.; *Editor*, E. Porter Felt, Nassau, Rens. Co., N. Y.—220.

ASSOCIATION OF TEACHERS OF MATHEMATICS IN THE MIDDLE STATES AND MARYLAND.

President, W. E. Breckenridge, Stuyvesant High School, New York City; *Vice-President*, Louisa M. Webster, Hunter College, New York City; *Secretary*, C. B. Walsh, Friends' Central School, Philadelphia, Pa.; *Treasurer*, Clarence P. Scobori, Polytechnic Prep. School, Brooklyn, N. Y.; *The Council*, William Betz, Rochester, N. Y.—220.

CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

(*Annual Meeting*, November 25, 26, 27, *at Englewood High School, Chicago.*)

President, J. A. Foberg, Crane Technical High School, Chicago; *Vice-President*, Frederick R. Gorton, State Normal College, Ypsilanti, Mich; *Treasurer*, Lewis L. Hall, Morgans Park High School, Chicago; *Corre-*

Digitized by Google

Blakiston

TOWER, SMITH, TURTON AND COPE

Physics

A textbook, besides imparting to the pupil the actual information sought, should inspire him to original effort and the consequent mastery of each problem. It should be a stimulus, a challenge and a guide to thinking about familiar physical phenomena with the aim to make the pupil study physics, not in the class-room alone, but on the street, in the car, and in his home. That is the aim of the present work.

With 455 Illustrations, Including 7 Plates. Cloth, $1.35 Postpaid.

* * *

AHRENS, HARLEY AND BURNS

Practical Physics Manual

While the study of physics of daily life is the keynote of the modern textbook, many of the laboratory manuals still adhere to the old method leaving the presentation of material from every-day life in the textbook alone. The present manual departs from the old method. Experiments are arranged for convenience in three distinct courses: general course; technical course; household physics course.

With 133 Illustrations. Cloth, $1.25 Postpaid.

* * *

NEUFELD

By J. L. NEUFELD, Central High School, Philadelphia

Elementary Algebra

With Table of Logarithms

"I couldn't understand the explanation in the book." How much of the teacher's and pupil's time is consumed and development of the class delayed by the necessity of reassigning work because the textbook fails to make the point clear? A new book which will correct this fault is now available. It is a work by an author of long experience. There are many special features of value which make the book of more than ordinary interest. An examination of this text will convince.

Illustrated. Ready in May.

P. BLAKISTON'S SON & CO.

PUBLISHERS **PHILADELPHIA**

Digitized by Google

sponding Secretary, Ally L. Marlatt, University of Wisconsin, Madison; *Assistant Treasurer*, E. S. Tillman, High School, Hammond, Indiana; the *Recording Secretary*, Harry O. Gillet, the University of Chicago, was elected last year for a two-year term. *Section Officers for 1920:*

Biology—Chairman, Grace J. Baird, Bowen High School, Chicago; *V.-Chairman*, C. P. Shideler, Joliet Twp. High School, Joliet, Ill.; *Secretary*, Elizabeth Foss, North High School, Minneapolis, Minn.; *Chemistry—Chairman*, B. J. Rivett, Northwestern High School, Detroit, Mich.; *V.-Chairman*, George Sype, Austin High School, Chicago; *Secretary*, K. J. Stouffer, Wayland Academy, Beaver Dam, Wis.; *General Science—Chairman*, G. A. Bowden, University School, Cincinnati, Ohio; *V.-Chairman*, George Mounce, LaSalle-Peru Twp. High School, LaSalle, Ill.; *Secretary*, Ruth C. Russell, Lake View School High, Chicago; *Geography—Chairman*, Wellington D. Jones, The University of Chicago, Chicago; *V.-Chairman*, R. R. Robinson, Joliet Twp. High School, Joliet, Ill.; *Secretary*, Anne B. Royeston, Hyde Park High School, Chicago; *Home Economics—Chairman*, Harriet Glendon, Lewis Institute, Chicago; *V.-Chairman*, Treva E. Kauffman, Ohio State University, Columbus, Ohio; *Secretary*, Maude M. Firth, Supervisor Home Econ., Davenport, Ia.; *Mathematics—Chairman*, M. J. Newell, High School, Evanston, Ill.; *V.-Chairman*, W. E. Beck, High School, Iowa City, Iowa; *Secretary*, Elsie G. Parker, Oak Park High School, Oak Park, Ill.; *Physics—Chairman*, H. Clyde Krenerick, North Div. High School, Milwaukee, Wis.; *V.-Chairman*, C. F. Phipps, State Normal School, DeKalb, Ill.; *Secretary*, Glenn W. Warner, Englewood High School, Chicago.—1119.

BOTANICAL SOCIETY OF AMERICA.

President, N. L. Britton, New York Botanical Garden; *Vice-President*, C. E. Allen, University of Wisconsin; *Secretary*, J. R. Schramm, Cornell University, Ithaca, N. Y.; *Treasurer*, Edmund W. Sinnott, Connecticut Agricultural College, Storrs, Conn.—320.

CHEMISTRY TEACHERS' CLUB OF NEW YORK CITY.

President, Alton I. Lockhart, Horace Mann School, New York City; *Vice-President*, J. Ellis Stannard, Boy's High School, Brooklyn, N. Y.; *Secretary*, Floyd L. Darrow, Polytechnic Preparatory Country Day School, Brooklyn, N. Y.; *Treasurer*, J. Hood Branson, Evander Childs High School, Bronx, N. Y.

ECOLOGICAL SOCIETY OF AMERICA.

President, Barrington Moore, American Museum of Natural History, New York City; *Secretary*, Dr. A. O. Weese, University of New Mexico, Albuquerque, N. M.—220

GENERAL SCIENCE CLUB OF NEW ENGLAND.

President, J. Richard Lunt, Poston English High School; *Vice-President*, W. H. D. Meier, Framingham Normal School; *Secretary*, Edith L. Smith, Poston Normal School; *Treasurer*, C. H. Stone, Boston English High School.—320.

ILLINOIS ACADEMY OF SCIENCE.

President, Henry B. Ward, University of Illinois; *Vice-President*, Geo. D. Fuller. University of Chicago; *Secretary*, J. L. Pricer, State Normal University, Normal; *Treasurer*, W. G. Waterman, Northwestern University.—319.

IOWA ACADEMY OF SCIENCE.

President, S. W. Beyer, Iowa State College, Ames; *First Vice-President*, T. C. Stephens, Morningside College, Sioux City; *Second Vice-President*, R. Monroe McKenzie, Parsons College, Fairfield; *Secretary*, James H. Lees, Iowa Geological Survey, Des Moines; *Treasurer*, A. O. Thomas, State University, Iowa City.—318.

INTERNATIONAL METALLURGICAL AND CHEMICAL SOCIETY.

President, Leo A. Cawes; *Vice-President*, Carl Valdemar; *Secretary* and *Editor*, Roy Franklin Heath, c-o Billings Polytechnic Institute, Billings, Montana.—320.

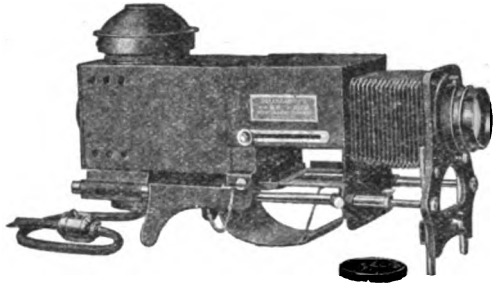
IOWA ASSOCIATION OF MATHEMATICS TEACHERS.

President, W. J. Rusk, Grinnell College, Grinnell, Iowa; *Vice-President*,

Digitized by Google

Spencer Transposer

The only real Stereopticon Advance in Twenty-five years

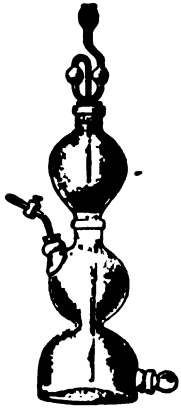


SPENCER DELINEASCOPE

FOR PROJECTION OF LANTERN SLIDES

Incorporates many new features among which are: **Nitrogen filled Mazda Lamp** *and* **Spencer Transposer** for handling the slides, giving a dissolving effect with but one outfit only (*not two*) and doing away with the old style cumbersome slideholder. Illustrated and described in catalog sent free on request. ∴ ∴ ∴ ∴

Spencer Lens Company Buffalo, N. Y.



No. 2402

We Carry a Complete Stock of

Chemicals & Apparatus

for the

Physical

Agricultural

Chemical

Biological

Laboratory

We Excel in Equipping High School Laboratories.
Let Us Quote Prices on Your Next List of Requirements.

THE KAUFFMAN-LATTIMER CO.

41 East Chestnut Street
Columbus, Ohio

Digitized by Google

O. F. Nixon, Principal of High School, Fairfield, Iowa; *Secretary-Treasurer*, Ira S. Condit, Iowa State Teachers College, Cedar Falls, Iowa.—120.

IOWA SECTION OF THE MATHEMATICAL ASSOCIATION OF AMERICA.

President, Ira S. Condit, Iowa State Teachers College, Cedar Falls, Iowa; *Secretary*, Le Roy Coffin, Coe College, Cedar Rapids, Iowa.—120.

KANSAS ASSOCIATION OF MATHEMATICS TEACHERS.

President, J. A. G. Shirk, Pittsburg, Kansas, one year; *Vice-President*, Emma Hyde, Emporia, Kansas, one year; *Secretary-Treasurer*, Edna E. Austin, No. 6 The Devon, Topeka, Kansas, three years.—1119.

MATHEMATICAL ASSOCIATION OF AMERICA.

President, David Eugene Smith, Teachers College, Columbia University; *Vice-Presidents*, Helen A. Merrill, Wellesley College, Wellesley, Mass., and E. J. Wilczynski, University of Chicago, Chicago, Ill.; *Secretary-Treasurer*, W. D. Cairns, Oberlin College, 27 King Street, Oberlin, Ohio.—120.

NATIONAL EDUCATION ASSOCIATION.

President, Josephine Corliss Preston, Olympia, Wash.; *Secretary*, J. W. Crabtree, Washington, D. C.; *Treasurer*, A. J. Matthews, Tempe, Ariz.; *Department of Secondary Education: President*, W. W. McIntire, Principal Norwood High School, Norwood, Ohio; *Vice-President*, Charles H. Perrine, Principal Wendell Phillips High School, Chicago, Ill.; *Secretary*, Anna Willson, Principal High School, Crawfordsville, Ind.; *Department of Higher Education: President*, Guy Stanton Ford, University of Minnesota, Minneapolis, Minn.; *Secretary*, J. J. Pettijohn, Director Educational Extension, Bureau of Education, Washington, D. C.; *Department of Normal Schools: President*, John R. Kirk, President State Normal School, Kirksville, Mo.; *Secretary*, Anna M. Tibbetts, Fargo College, Fargo, N. D.; *Vice-President*, Joseph Rosier, President Fairmont State Normal School, Fairmont, W. Va.; *Department of Science Instruction: President*, George R. Twiss, Ohio State University, Columbus, Ohio; *Vice-President*, James H. Smith, Assistant Principal, Austin High School, Chicago, Ill.—719.

MISSOURI SOCIETY OF TEACHERS OF MATHEMATICS AND SCIENCE.

Department of Mathematics and Science: President, O. M. Stewart, Columbia, Mo.; *Secretary*, B. F. Finkel, Drury College, Springfield, Mo.; *Treasurer*, A. J. Schwartz, St. Louis, Mo.; *Mathematics Division: Vice-President*, W. A. Luby, Kansas City; *Secretary*, Eula Weeks, St. Louis, Mo.—419.

NEW ENGLAND ASSOCIATION OF CHEMISTRY TEACHERS.

President, William W. Obear, High School, Somerville, Mass.; *Curator*, Lyman C. Newell, Boston University, Boston, Mass.; *Secretary*, S. Walter Hoyt, Mechanic Arts High School, Boston, Mass.; *Treasurer*, Alfred M. Butler, High School of Practical Arts, Boston, Mass.—120.

NEW ENGLAND ASSOCIATION OF TEACHERS OF MATHEMATICS.

President, William R. Ransom, 29 Sawyer Ave., Tufts College, Mass.; *Vice-President*, Edmund D. Searles, High School, New Bedford, Mass.; *Secretary*, Harry D. Gaylord, 448 Audubon Road, Boston, Mass.; *Treasurer*, Harold B. Garland, High School of Commerce, Boston, Mass.—1218.

NEW JERSEY SCIENCE TEACHERS' ASSOCIATION.

President, Merton C. Leonard, Dickinson H. S., Jersey City; *Vice-President*, Walter J. Dumm, Barringer H. S., Newark; *Secretary-Treasurer*, Carl J. Hunkins, South Side H. S., Newark; *Recording-Secretary*, Agnes V. Luther, Newark Normal School, Newark; *Chairman Biology Section*, F. H. Hodgson, High School, Montclair; *Secretary Biology Section*, Miss L. H. Seeley, Dickinson H. S., Jersey City; *Chairman Chemistry Section*, C. E. Dull, South Side H. S., Newark; *Secretary Chemistry Section*, Miss Pauline McDowell, Battin H. S., Elizabeth; *Chairman Physics Section*, W. H. Platzer, High School, Kearny; *Secretary Physics Section*, Carl O. Voegelin, Central C. & M. T. H. S., Newark; *Chairman Elementary Science Section*, Miss Edith L. Spencer, South Side H. S., Newark; *Secretary Elementary Science Section*, Miss Julia G. Pierce, High School, Paterson; *Members at large of the Executive Committee*, Dr. M. T. Cook, Rutgers College, New Brunswick, and Miss Edith S. Merritt, Dickinson H. S., Jersey City.—120.

Digitized by Google

Vol. XX. No. 7 Whole No. 171

OCTOBER, 1920

SCHOOL SCIENCE AND MATHEMATICS

A Journal for All Science and Mathematics Teachers

Founded by C. E. Linebarger

SMITH & TURTON, Publishers

Publication Office, Mount Morris, Illinois

CHICAGO OFFICE, 2059 East 72nd Place, CHICAGO, ILL.

CHARLES H. SMITH
EDITOR
Hyde Park High School, Chicago

CHARLES M. TURTON
BUSINESS MANAGER
Bowen High School, Chicago

DEPARTMENTAL EDITORS

Agriculture—Aretas W. Nolan
The University of Illinois, Urbana, Ill.

Astronomy—George W. Myers
The University of Chicago

Biology, Research in—Homer C. Sampson
The Ohio State University, Columbus

Botany—Worralo Whitney
Hyde Park High School, Chicago

Chemistry—Frank B. Wade
Shortridge High School, Indianapolis, Ind.

Chemistry, Research in—B. S. Hopkins
The University of Illinois, Urbana, Ill.

Earth Science—William M. Gregory
Normal Training School, Cleveland, Ohio

General Science—Fredric D. Barber
State Normal University, Normal, Ill.

Mathematics—Herbert E. Cobb
Lewis Institute, Chicago

Mathematics Problems—Joseph A. Nyberg
Hyde Park High School, Chicago

Physics—Willis E. Tower
Englewood High School, Chicago

Physics, Research in—Homer L. Dodge
The State University of Oklahoma, at Norman. Representing American Physical Society

Science Questions—Franklin T. Jones
Warner and Swasey Co., Cleveland, Ohio

Zoology—Harold B. Shinn
Schurz High School, Chicago

Published Monthly October to June, Inclusive, at Mount Morris, Illinois
Price, $2.50 Per Year; 30 Cents Per Copy

Entered as second-class matter March 1, 1913, at the Post Office at Mount Morris, Illinois, under the Act of March 3, 1879

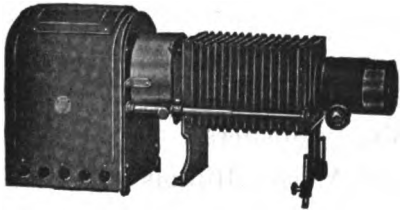
Digitized by Google

"McIntosh Lanterns Are Honest Lanterns."

Lantern Slides of Science

A copy of our Catalogs of science slides was mailed when published to every member of the Central Association. Are you a member? Did you get your copy? Did you keep it?

If not, there is another copy for you if you are interested. Just write us a card and ask for it. No obligation. You'll need it in placing your orders for science slides.



Lanterns from $43.00 up. Opaque and micro projectors, slides and accessories.

McINTOSH STEREOPTICON COMPANY
410 Atlas Block, CHICAGO, ILL.

VIVIAN'S

EVERYDAY CHEMISTRY

"The Chemistry of Life—Not of Books"

New York
Chicago
Cincinnati
Boston
Atlanta

AMERICAN BOOK COMPANY
330 East Twenty-second Street
CHICAGO, ILLINOIS

Digitized by Google

SCHOOL SCIENCE AND MATHEMATICS

VOL. XX, NO. 7 OCTOBER, 1920 WHOLE NO. 171

RESEARCH IN CHEMISTRY.

Conducted by B. S. Hopkins,
University of Illinois, Urbana.

It will be the object of this department to present each month the very latest results of investigations in the pedagogy of chemistry, to bring to the teacher those new and progressive ideas which will enable him to keep abreast of the times. Suggestions and contributions should be sent to Dr. B. S. Hopkins, University of Illinois, Urbana, Ill.

ACTIVATED NITROGEN.

BY F. O. ANDEREGG, *Professor of Physical Chemistry, Purdue University, Lafayette, Ind.*

One of the essential constituents of all living matter is nitrogen. One of the things the farmer has to worry about is how to secure nitrogen with which to grow his crops and yet there are tons and tons of this very valuable substance all about him for it comprises nearly four-fifths of the air. Above every square inch of the surface of the earth there are about twelve pounds of nitrogen. Unfortunately it is very inert. The inertness is caused by the combination of two nitrogen atoms, which are reactive enough by themselves, into a very stable molecule. The two atoms have such an affinity for each other that it is only with considerable difficulty that they can be pulled apart sufficiently to react with other substances—such as oxygen. It is the problem of the chemist to devise successful methods for activating nitrogen. How well this has been done is shown by the plentiful supply of ammunition with which the Germans provided themselves by activating atmospheric nitrogen for the formation of nitric acid which is necessary in making almost all explosives.

It is not the purpose of this discussion to take up the present practical methods for nitrogen fixation. There is a very considerable amount of literature on this interesting subject. Our

Digitized by Google

object is to discuss some of the less well known methods of activating nitrogen. It is true that these are not of present practical value, but the laboratory experiment of today which seems to have only theoretical importance becomes the basis for the practical method of tomorrow or of next year and so it behoves us as wide awake scientists to keep up with the times and perhaps even to anticipate them.

E. Percival Lewis of the University of California prepared some nitrogen chemically from ammonium nitrite and on subjecting this to a discharge from an induction coil at a pressure of a few millimeters of mercury he noted the formation of a pulsating yellow mist in the tube and which also extended outside the tube for some distance. On breaking the circuit the glow persisted for several seconds. In order to get this afterglow the purity of the nitrogen had to be carefully adjusted. If it was prepared from air and quite free from oxygen it gave very little if any glow. The chemically prepared material contained traces of nitric oxide which seemed, at first, to be necessary to catalize the reaction. Also a so-called condensed discharge appeared to work best. This was secured by placing a few Leyden jars in parallel with the discharge tube.

R. J. Strutt, an English physicist, has continued the study of this afterglow and has found that it has a great many peculiar physical and chemical properties. When the glowing nitrogen passed through a tube which was heated locally, the glow was extinguished but reappeared on the other side. When cooled by liquid air the luminosity increased momentarily and was then finally extinguished. Similarly on compression the glow was extinguished, indicating that the return to the inert form was a polymolecular reaction. The molecular change back to the ordinary inert nitrogen was then accelerated by cooling and retarded by heating. The glowing gas had a conductivity like a salt flame due to the presence of some ions; but on applying an electric field of two hundred volts to the luminous nitrogen, the glow was not diminished, indicating that the afterglow was not produced by nitrogen atoms or molecules, bearing charges.

Action on non metals: The chemical properties of glowing nitrogen were very interesting. In contact with phosphorus a violent reaction took place and some red phosphorus was deposited, and on precipitating the compound by cooling in liquid air over 15 mg. were secured from 2.5 liters of nitrogen, indicating

Digitized by Google

that nearly 0.5 per cent of the nitrogen had combined with phosphorus. When the glowing nitrogen came in contact with iodine vapor a magnificent light blue flame was produced. But on hydrolyzing the product with potassium hydroxide no trace of ammonia was secured. It might have been that iodine united with nitrogen as oxygen does, so that on hydrolysis nitric acid was formed rather than ammonia. In contact with warmed sulfur a bluish glow was formed with a green deposit on the glass. With selenium, arsenic, antimony and carbon, very little if any reaction was to be noted. When hydrogen was added the glow was diminished by the dilution but there was no evidence of ammonia formation. When oxygen was added to the active nitrogen the glow was simply extinguished, no trace of oxides of nitrogen being formed.

Action on metals: When activitated nitrogen came in contact with melted sodium a great deal of yellow light was developed. The yellow D sodium line predominated in the spectrum. This yellow coloration was so vivid that it served as a convenient sensitive test for the presence of active nitrogen. In contact with the vapors of several other metals, chemical reaction took place accompanied by light. A fresh surface of mercury was covered with a coating of nitride which was apt to be explosive but there was no reaction at the clean cold surfaces of other metals.

Action on compounds: Moisture and carbon monoxide like hydrogen served merely to dilute the glow. On the other hand ammonia, like oxygen, caused the extinction of the light. Oxides of manganese and copper had a similar effect. When metallic salts which vaporize fairly readily, such as halogen compounds of tin, mercury and copper, were exposed to the afterglow, spectra were produced, characteristic of compounds like mercuric iodide, which are decomposed in the flame. Cyanogen gave a lilac color and characteristic spectrum.

Most of the hydrocarbons and some of their substituted products form hydrocyanic acid or nitriles with active nitrogen. Nitric oxide had a very interesting reaction. A greenish, continuous spectrum flame was produced. On cooling to 180° a dark blue substance condensed which melted on removing the liquid air to an indigo blue liquid. This in turn evaporated to an orange colored gas (NO_2) soluble in an hydroxide. On weighing, the condensed product showed that as high as 2.5 per cent of the nitrogen had been activated and had reacted probably according to the equation, $2NO + N\ (act) = NO_2 + N_2$.

Digitized by Google

After the publication of these results several Germans, especially Tiede and Domeke in 1913, objected to the idea of an active modification of nitrogen. They claimed that there was always present in Strutt's nitrogen traces of oxygen which were responsible for the reactions noted. Strutt had taken a great deal of pains with his nitrogen but there remained the possibility that there were present traces of oxygen. With the assistance of H. B. Baker he then took especial care to eliminate all the oxygen and although the afterglow was somewhat weakened it still persisted. The Germans were not willing to accept these results so it was arranged, not very long before the war broke out, for them all to get together in London and thresh the whole matter out. The results were published in 1914 by all four simultaneously in *Nature* and in the *Berichte* vindicating the claims of Strutt that an afterglow could be obtained without the presence of oxygen. However, very minute traces of oxygen were found to increase the amount of luminosity. A little later Strutt published another article in which he showed that a number of gases could be used to catalize this formation of active nitrogen. Oxygen, hydrogen, sulfur, chlorine, many carbon compounds and hydrogen at a concentration of about 0.1 per cent gave a very good yield while methane in traces corresponding to 0.003 per cent gave a distinct effect.

The mechanism of the catalytic action has been explained by Strutt on the basis of certain observations of J. J. Thomson made on positive rays. If in a tube built for a vacuum discharge, a fine hole is bored through the cathode or negative electrode, then some of the positive ions will pass right through this hole and by means of magnetic and electrostatic fields can be caused to deviate so that the substances which carry the charges can be analyzed in a very beautiful manner. Some few of the positive ions are capable of not only losing their charge but also of picking up negative charges. Such substances are oxygen, hydrogen, carbon, sulfur and chlorine, all of which Strutt has found to be helpful in increasing the yield of active nitrogen. Therefore Strutt thought that it may be these negatively charged atoms which, by collision, were especially effective in activating nitrogen.

More recently another active form of nitrogen has been discovered by Mr. A. C. Grubb, working with Dr. G. L. Wendt at the University of Chicago, using an alternating corona discharge tube devised by Mr. K. B. M. McEachron of Purdue University.

Digitized by Google

A platinum wire is inserted in the middle of an ordinary Liebig condenser which is connected with one terminal of a high voltage transformer. The jacket of the condenser is filled with a conducting solution and is connected with the other terminal of the transformer, which is also grounded to reduce the danger. The glass wall of the inner tube serves as dielectric and as the solution keeps the dielectric cool the danger of puncturing it is lessened sufficiently so that a high enough voltage can be applied to fill the gas space with a gorgeous corona discharge. The activated nitrogen obtained in this way is more active than that variety studied by Strutt. It readily reacts with cold alkali metals while the other reacts only with heated metals. This newer variety reacts with cadmium, magnesium, aluminum and iron at far lower temperatures than does the other form. With ordinary oxygen it forms nitric acid, while with hydrogen, ammonia is produced. These reactions were not carried out with Strutt's nitrogen. On subjecting nitrogen to continuous discharge as high as 4 per cent of the active form is produced. It possesses also an odor somewhat like iodoform. The discoverers give to it the name of "nizone."

It is doubtless due to some such activated nitrogen that oxidation of nitrogen occurs in the silent discharge. The question of the commercial production of nitric acid in the silent discharge at ordinary temperatures is being investigated at the Engineering Experiment Station of Purdue University and sufficiently promising results have been secured to warrant studying the whole question quite thoroughly. In the fixation of nitrogen the most important phase of the problem is to obtain the activation of the nitrogen. It is not necessary to activate the nitrogen to the extent that either the Strutt or the Grubb nitrogen is activated because there is present in air while in the discharge fairly large amounts of oxygen more active than ordinary oxygen. There are apparently several steps in the activation of nitrogen. In addition to the ordinary, extraordinarily inert molecular nitrogen in various types of discharge, there are formed: the nitrogen studied so extensively by R. J. Strutt, that more recent discovery of Grubb and Wendt, and also probably atomic and most certainly ionic nitrogen. The ions, according to J. J. Thomson, are positively charged atoms and molecules.

The study of activated nitrogen is a very important one both for theoretical reasons and for practical purposes. When we understand just what limitations are placed upon the activa-

Digitized by Google

tion of nitrogen by the structure of its molecule we shall be in a position to know what will be the best methods to employ in its commercial fixation and just what efficiencies to expect in practice. A great deal of research is being carried out in this country as well as abroad and there is a very keen competition as to who shall make the greatest contribution to our knowledge in this most important field of chemical endeavor.

BIBLIOGRAPHY.

E. P. Lewis, *Astrophys. J.* **12**, 8 (1900); 20, 49 (1904) *Ann. Physik.* [4], **2**, 459 (1900); *Phys. Rev.* **18**, 125 (1904); *Physik. Z.* **5**, 546 (1904).
E. Warburg, *Ann. Physik*, [4], **10**, 180 (1903).
Von Nosengeil, *Ibid*, **20**, 833 (1906).
R. J. Strutt, *Proc. Roy. Soc. London. A.* **85**, 219 (1911). **86**, 56,262 (1912), **87**, 179,302 (1913); **88**, 539 (1915). *Physik. Z.* **14**, 74, 215 (1913); **15**, 274 (1914). *Engineering* **95**, 330 (1913).
R. J. Strutt and A. Fowler, *Proc. Roy. Soc. London. A.* **85**, 377 (1911) **86**, 105 (1912).
H. B. Baker and R. J. Strutt, *Physik. Z.* **15**, 274 (1914); *Ber.* **47**, 801, 1049 (1914).
W. Jevons, *Proc. Roy. Soc. London A.* **89**, 187 (1913).
F. Comte, *Physik. Z.* **14**, 74 (1913).
A. Koenig and E. Eloed. *Ibid*, **14**, 165 (1913). *Ber.* **47**, 523 (1914).
Erich Tiede, *Ber.* **46**, 340 (1913).
E. Tiede and Emil Domcke, *Ibid*, **46**, 4095 (1913); **47**, 420 (1914).
H. B. Baker, Erich Tiede, R. J. Strutt, Emil Domcke (all together) *Nature*, **93**, 478 (1914) and *Ber.* **47**, 2283 (1914).

ASPHALT IN THE UNITED STATES, A GREAT UNDEVELOPED RESOURCE.

Few mineral deposits in America are more promising to the prospector or more interesting to the scientist than the asphalt deposits of California, Kentucky, and the Rocky Mountain and Mid-Continent States, according to a report just issued by the United States Geological Survey, Department of the Interior. There are no deposits in the United States equal in size and purity to the mysterious pitch lake of Trinidad, from which asphalt has been taken for paving the famous thoroughfares of the world for many years without materially lowering its surface, but there is a great quantity of bituminous rock that could be used locally in surfacing our vast mileage of unimproved highways. Native asphalt, although one of our great undeveloped natural resources, has not been extensively mined because of the former abundance of asphaltic petroleum and because of our large imports, but now bituminous products of many varieties obtained from domestic deposits could adequately supply the requirements in several parts of the country.

As asphalt is formed from petroleum and is a remarkable preservative, it has long been a subject of absorbing interest to the oil geologist and the paleontologist. Many of the surface deposits throughout the country, like that near Los Angeles, Calif., which yielded remains of the extinct saber-toothed tiger, were formed in recent or Pleistocene time, but some are much older. The asphalt formations range in thickness from a few inches to many feet, and as they are associated with petroleum both geographically and stratigraphically and are of like origin and composition, they may be roughly assigned to the same fields.

Digitized by Google

PHYSICAL TESTS.

By Marion D. Weston, Ph. D.

Rhode Island College of Education, Providence.

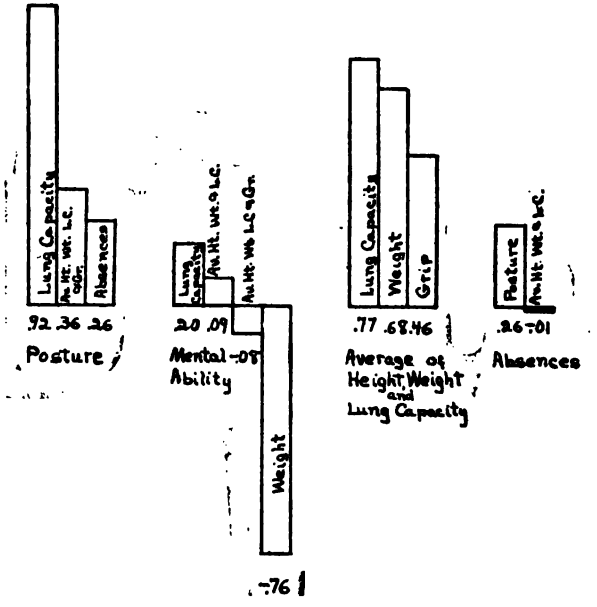
Physical tests are often given to pupils entering secondary schools and colleges, for the purpose of determining defects which may be remedied by suitable gymnastic work. Frequently no attempt is made to compare the pupil's record with any standard. As a result even if the pupil receives his record he has no means of knowing whether he is above or below others of his age and height. Physical measurements, such as height, weight, lung capacity and strength of grip, are far less frequently taken in elementary schools, where their need is, if anything, greater. These tests aim to discover deviation from the normal or standard and to help pupils improve themselves. The mere statement of what a child should weigh and what he does weigh placed in his own hands and also sent to his parents is a step in the right direction. Suggestions for increasing weight, in case he is underweight, will meet with respectful attention and frequently earnest effort to follow directions, for the desire for physical perfection is fortunately very keen in most human beings.

The problem of finding adequate figures for comparison is a very serious one. I have been able to get hold of only one set which gives lung capacity and strength of grip as well as height and weight. The fact that more have not been worked out proves that very little importance is being attached to comparisons with averages. The abundance of standards for mental tests is in marked contrast to the condition met with in physical tests and measurements. Possibly an even more serious difficulty is the lack of proof as to the real significance of the various measurements, the relative importance of the different tests. Which test gives the best index of general physical well-being? Is there any relationship between physical and mental ability? Correlations which may throw some light on these questions have been worked out by the writer from the figures obtained from a survey of grades I–VIII in a Rhode Island school during the year 1919.

Five tests were included in the survey: height, weight, lung capacity and strength of grip of right and left hands. Lung capacity was taken with a spirometer with scale reading in cubic inches; strength of grip with hand dynamometer reading pres-

Digitized by Google

sure in pounds. By lung capacity is meant the amount of air which can be expelled from the lungs after a deep breath has been taken in; by strength of grip the amount of pressure which the muscles of the arm enable the hand to bring to bear on the dynamometer. As the effort to make a good record makes a decided difference in some of the physical measurements, the examiners endeavored to give each child the same amount of encouragement, such as the direction, "stand up straight and tall." Demonstrations of spirometer and dynamometer were always made. Considerable explanation was frequently necessary with the younger children before satisfactory results could be secured.



The figures obtained were compared with the averages published by Dr. Thomas D. Wood, Teachers College, Columbia University. As a convenient way of expressing a child's relation to his own average, the individual child's record in each of the five measurements was divided by the average, found by Dr. Wood, for a child of his sex, age and height. The five decimals thus obtained were averaged, giving a figure which may be considered to represent his physical standing. Remedial work with the children found decidedly below average in lung capacity and weight is now being carried on by the school. The children have also been given posture tests by Miss Edith Haight, making possible correlations between posture and other

Digitized by Google

physical measurements. Records of absences for the second semester, 1918-1919, were obtained with the idea that attendance indicates to a certain extent the general health of the pupil, the reason for absence generally being personal illness. This assumption is doubtless safer with young children than with pupils of high school age who may be detained at home for household duties.

Correlations with mental ability were made possible by a survey of the same school with thirteen standard tests of intelligence and efficiency, made by Dr. Grace E. Bird during the year 1919.

The suspicion that strength of grip has little connection with the other physical measurements was corroborated by the correlation .59 between lung capacity and the average of height, weight, lung capacity and grip as compared with the correlation .77 between lung capacity and the same average minus grip. As strength of grip probably depends entirely on the customary occupation of the individual, it is easily conceivable that a person with poor records in this one respect may rank high in the other measurements. One remarkably high grip record was explained by the fact that the child sold newspapers. The same amount of time spent out of doors in active play would probably yield as satisfactory lung capacity but far lower grip records. In the comparison of the average of height, weight and lung capacity with grip the correlation was found to be .46, showing the relationship to be small. Although the dynamometer test is a favorite with children and young people alike and doubtless registers a wholesome tendency, it does not seem to be sufficiently important to warrant much attention as an indication of general health.

The correlation .77 between the average of height, weight, lung capacity and lung capacity as compared with .68 between the same average and weight suggests that lung capacity records agree a trifle more closely with the average than is the case with weight. The difference, however, is so slight that probably either measurement may be taken as a fair index of the child's general health. Weight is more often used. The Child Health Organization urges that scales be placed in every school building and that a child's weight record with his standard should be sent home each month. Since scales are so common in stores and other public places and spirometers are rare it is best to emphasize weight records although, according to these figures, lung capacity seems to be a trifle more significant.

Digitized by Google

Lung capacity also correlates very high with posture, .92. The relationship is no closer, however, than would be expected from the effect good posture is known to have on the size of the thoracic cavity, which in turn controls the space occupied by the lungs. It is probable that better general health as well as greater immunity from respiratory diseases will accompany improvement in lung capacity, but I know of no figures to offer in proof. A partial experiment was made with a group of normal school students in the spring of 1919. Freedom from severe colds seemed to be rather more general among the girls who were above the average in lung capacity. No correlations were worked out. Since the many advantages, both mental and physical, claimed for correct posture are probably in the main true and since, as will be shown later, there is some correlation between lung capacity and mental ability, there seems every reason to stress both posture and lung capacity. Both are easily improved by young people with a little conscious effort, which will yield immeasurably large returns. There is no greater incentive to improvement than frequent measurements to prove that results are really being obtained. It would seem that the correlation between lung capacity and posture is so high that repeated tests of both are unnecessary. A good posture test, which can be given without apparatus and to a considerable group, may be substituted for the lung capacity measurements which cannot easily be taken without a spirometer and must be given individually. Another measurement, which would probably answer the purpose, is girth of chest. The tape measure alone is necessary for this test. The necessity for individual work and the added amount of time involved make this measurement less desirable than the posture. No figures were collected on this particular measurement. There is a suggestion of relationship between the average of height, weight, lung capacity, grip and posture as shown by the correlation .36. Record of attendance compared with posture gives the correlation .26 as compared with .01 between average height, weight, lung capacity and attendance. If constant attendance is evidence of good health or at least resistance to disease, as it seems safe to assume, then apparently more can be told about a child's health from his posture than from the average of his other physical measurements.

A conspicuous lack of correlation between physical and mental ability is apparently shown by the three comparisons: lung

Digitized by Google

capacity and mental .20; average height, weight, lung capacity, grip and mental .−08; weight and mental .−76. The last mentioned is so very low that it almost suggests that underweight might compare more favorably. The question of malnutrition is of such vital importance in children's health that this correlation is particularly surprising. With adults, where overweight, at least after 35, is a more serious condition than underweight, the problem is different. The close relationship between lung capacity and mental ability suggested by Dr. Stuart Courtis, although not confirmed by the low correlation .20, is partially supported by the fact that this correlation is positive, whereas the comparison with average of height, weight and lung capacity and also with weight alone gave negative results. It would seem, therefore, that the relationship between lung capacity and mental ability is closer than with the other physical measurements. It is possible that better results would be obtained with adults where the factor of rapid growth would not enter in to divert energy from mental work. This may be a different question from the one partially answered by the correlation .20 which is a comparison of conditions in different children rather than a series of records from one group. To attempt to answer this question would involve an entirely different and far more difficult experiment. External factors here, as in all experiments with health conditions, are very difficult to control. The group tested should be consciously striving to improve lung capacity but should not know that any special significance is being attached to the mental tests, which should come in as a part of the regular school work.

This work with physical tests, though crude, has proved suggestive. No claim to refinement of method is claimed for the experiments. Variability for age was considered only in terms of sex and height. Although other factors should doubtless be taken into account, with the present lack of standards for comparison this was not possible. Of course, the number of cases is too small to make any results conclusive. The following conclusions are offered with these limitations in mind.

1. Muscular strength, as indicated by grip measurements, does not necessarily mean good general health. There seems to be little relationship with other physical measurements.

2. Weight correlates well with the average of the physical records. It is probably a very significant measurement for children.

Digitized by Google

3. Lung capacity is apparently the most significant record from both physical and mental standpoints. Since the correlation with posture is very high, it is probable that the latter test may be substituted for the spirometer readings.

4. With the single exception of lung capacity no connection between mental and physical ability is indicated by these correlations.

Table showing range, median and quartile deviation:

Measurement.	Range.	Median.	Quartile Deviation.
Weight	.75-1.47	1.05	.05
Lung Capacity	.51-1.30	1.98	.08
Average of grip of right and left hands	.72-1.49	1.02	.06
Average of height, weight, and lung capacity	.79-1.24	1.01	.05
Average of height, weight, lung capacity and grip	.77-1.32	1.02	.06

The median was found by the rough formula $n+1/2$ without correction.

The Quartile Deviation was found by Yule's formula: $Q=(Q_3-Q_1)/2$.

CORRELATIONS.

Posture and lung capacity	.92	125 case
Average height, weight, lung capacity and lung capacity	.77	218 case
Average height, weight, lung capacity and weight	.68	101 case
Average height, weight, lung capacity, grip and lung capacity	.59	218 case
Average height, weight, lung capacity and grip	.46	218 case
Average height, weight, lung capacity, grip and posture	.36	111 case
Absences and posture	.26	111 case
Lung capacity and mental ability	.20	55 case
Average height, weight, lung capacity and mental ability	.09	55 case
Average height, weight, lung capacity and absences	−.01	109 case
Average height, weight, lung capacity, grip and mental ability	−.08	55 case
Weight and mental ability	−.76	55 case

The correlation formula $\frac{1-\Sigma d^2}{n(n^2-1)/6}$ was used. The cases were arranged in order of merit regardless of grade because each child's record was being compared not with an absolute standard but with an average taking into account sex, age and height.

Digitized by Google

THE USE OF PHYSICAL EQUIPMENT OF THE SCHOOL BUILDING IN CLASSROOM INSTRUCTION.[1]

By Dean E. S. Keene,

School of Mechanic Arts, N. Dak. Agr. Col., Fargo, N. Dak.

When the United States entered the war, much occurred to show that we have entered into a new period of living. Men went to schools, the like of which had never before been a part of our educational system. Our armies learned things with fewer textbooks than were ever before provided for learners. Civilians began to acquire a new knowledge. They are still learning.

During the summer just past, this change was expressed in a most remarkable manner. At a live stock sale in western Minnesota a Holstein bull, Sir Pieterje Ormsby Mercedes 41st, sold at auction for $65,000. A few weeks later a Guernsey bull in Texas sold for $62,000. These are not the highest prices paid for such animals. In New York, somewhat earlier in the year, a Holstein bull, Rag Apple the Great, sold for $125,000. When such sums of money are paid for the means of propagating milk-producing stock, these incidents are sufficient to cause us to wonder at the change in the milk man. He used to appear in the morning with a big can, in a little covered wagon, smelling of unventilated barns, and announce his presence with a bell. His milk was universally sold at 5 cents a quart. Its quality was unknown. His customers knew nothing about it. It was just milk. Today we have in the place of this happy-go-lucky milk man, a milk producing company, regulated in all its branches by methods that are quite scientific. The old-time little business has been transformed into an industry. It affects every one of us and enters intimately into our lives. Milk is now known to be, not only a food that contributes to our contentment, that has to do with the comfort of the sick, the well-being of the convalescent and the lives of our babies, but also that one infected dairy may produce an epidemic of disease. Instead of any old milk, we demand pure milk.

Milk production, in those states that are sufficiently advanced in intelligence, is regulated by law and safeguarded by dairy commissioners. The laws are administered by milk inspectors. Tested cows that measure up to definite standard are recognized by all herdsmen. The cow as viewed by the dairyman, is a milk machine that must come up to a standard of efficiency or be

[1]Read before Section on General Science of the C. A. S. & M. T., at Lake View High School, Chicago, Nov. 28, 1919.

Digitized by Google

replaced. Milk must contain a minimum of butter fat. Butter must contain a minimum of water. Terms such as pasteurized milk, certified milk, Babcock test, cream separators, legal butter, processed butter mulsifiers and others that designate certain scientific standards, processes, and machines have to do with the operation of the milk industry. Ought we know about milk, its production, its preparation, distribution and purity? If so, when and where will it be taught, or is this information to be given alone in agricultural schools?

The milk industry is an example of the change that has taken place in practically all that affects domestic and business affairs. New methods of manufacture, improved ways of doing things, the application of new processes, unheard of demands, all seemed to focus and break out with the war.

New conditions of industry bring changed conditions of living; immediately then, a demand for better homes. This is not really a new demand, it is quite old in fact and has only been stimulated by the effect of the war.

The demand for better and more comfortable homes has been going on for years and has been the stimulus for the development of household machinery to a point such that the most modest cottage may be not only comfortable but possess the conveniences of water supply, heat, and light that were formerly accorded the few.

With this complication of domestic mechanism, that may seem to have suddenly descended upon us, there has come the necessity of keeping it in working order. In the past year, as never before, repair bills that formerly were modest, have assumed proportions that are startling. Not alone in repair bills but in the making of minor adjustments or the correction of slight disarrangements, many householders have been shown the advantage of a knowledge of household mechanics. When a woman watched a plumber replace a damaged filler-ball in a water tap at the cost of $4.50, she suddenly awakened to one means of reducing the high cost of living.

Of the things of prime importance, homes should come first of all and of a right should receive first consideration. The mechanism of homes should claim the attention of the schools. It is evident to those who teach such subjects that all applied science cannot be included in general courses of study. It is equally evident that some information should be given of mechanism and principles of operation included in household machinery.

Digitized by Google

The average science teacher is not familiar with domestic engineering, neither as to the functions of the machinery nor their method of operation. This, however, ought not deter an attempt at presenting a subject in which may be requisitioned the services of the school janitor, the fireman, the contractor, the plumber, the architect and anyone else who is in a position to help. The war taught us the value of such teachers. Much information may be imparted without textbooks.

Our laws have in many respects kept apace with industrial developments and in those states that have the most aggressive and the best guiding influence there has come legislation regulating the sale and use of solid, liquid, and gaseous fuels, electricity, water, weights and measures, and all else that has to do with the interest of the people. In this respect it is a matter of pride that Wisconsin and Illinois are among the foremost in formulating regulations that have served as guides for other states in conducting their affairs for the best interest of their citizens. All such laws and regulations are to be had free of charge by addressing the proper departments of the state. Summons of such regulations are easily made for presentation and become valuable information in every day life.

A comfortable home is the most desirable possession in family life. It is true that—"Be it ever so humble there is no place like home"; today as never before the home may be humble and comfortable at the same time. The comfort contributed by household conveniences are too well recognized to require discussion. Their mechanical perfection and adaptability are such as to make possible the complete equipment of any type of house and to suit any community. A knowledge of the various forms of domestic appliances, their mechanical construction and principles of operation contributed much to the general welfare of those who use them.

Every normal man and woman looks forward to the possession of a home. When the time arrives, the construction of the house involves many problems that have been considered only superficially or not at all. The result is much worry, anxiety, and often unnecessary expense with frequent unsatisfactory results because of a lack of information that ought to be common knowledge.

Suppose that a home is to be constructed anywhere outside of the corporate limits of a town and away from electric supply. It is to be provided with the usual conveniences. The house-

Digitized by Google

holder must consider in addition to the erection of the house, methods of heating, lighting, water supply, and sewage disposal. Aside from these he may consider many other items of secondary importance. If the house is to be built in a city, where a sewer system, water, and lights are available, the process involves consideration as to heating and plumbing, but away from the common sanitary facilities the difficulties are increased directly as their number.

The house is to be furnace-heated. The first question that comes to the owner is—what method of heating will be employed? Will it be a hot-water or a hot-air plant? This is often decided by advice of a friend, the architect or because of some personal experience, or knowledge of a house that seemed to be satisfactorily heated. It is quite unusual that the newlyweds know anything of household affairs. House heating having no place in the curriculum of the average school or college, it is rare that anything is known of house heating plants.

Suppose it is decided to heat the house with a hot-water plant. Now that the style is to be chosen, what type of hot-water plant is to be installed? Will it be a simple gravity system or a pressure system, for each of these have particular advantages that are worthy of consideration. If the hot-air plant has been chosen—the owner will be interested to know the most approved mechanical construction in choosing between various designs. He should understand the possibility of humidification in the hot-air plant. He should understand the mechanical construction of the furnace both as to the possibilities of repairs and the liability of gas leakage. At least he should know the elements of a well constructed heater.

Unless the various general features of a heating plant have been brought to his attention, he will probably not be aware of the methods of adapting a furnace to a building, nor its limitations. He does not comprehend excellence in workmanship or faulty construction and further it is likely that he does not understand the delivery of air to the various parts of the building, its gravitational flow, the size of conduits, and it is not at all likely that he knows anything of the physical properties of air.

Possibly the hot-air furnace man has talked well of the advantages of desirable atmospheric humidity that may be obtained with a hot-air plant and the advocate of a hot-water heating plant has told him of the deleterious effect of the dry air of such a

Digitized by Google

furnace, all of which is beyond his comprehension. With so much accessible material with which to illustrate, it is not at all difficult to point out the working principles of house heating.

The possibilities and limitations of steam as a heating agent is a convenient means of introducing the general subject of heating. The school heating plant furnishes an extensive laboratory of applied physics. The furnace, in the study of combustion, combined with the boiler furnishes the best possible example of heat generator. Such a plant may be made to show the relative commercial value of fuels. Its working principle is that of the heat of vaporization. The heating effect is produced by condensation. The heat distribution illustrates convection. It furnishes an excellent example of specific heat, the relative temperature and pressure of steam, and practically all of the laws of heat. The first principle of steam heating to be impressed on the learner is that the temperature of steam is of minor importance, that the heat of condensation supplies the heat in its radiator. Atmosphere humidity is a topic that has a place in every work on elementary physics and yet in its application there are few subjects so little understood. Imagine a highly educated person, one whose word is taken unquestioned by his friends, condemning a hot-air heating plant as objectionable, because of the "dryness of its heat," and emphatically stating that, "hot-water heat is much to be preferred because it gives a more humid atmosphere." Atmosphere humidity should be understood both because of its indoor effects and the difficulty of its maintenance, as well as the general atmospheric conditions that influence every season and all outdoor life. Most of us have been warned against breathing "night air"—as though there was some other form of air at night.

Most of the modern school heating plants are provided with air conditioning apparatus in which both relative and absolute humidity maybe and usually is beautifully illustrated.

In the mechanical construction of the boiler and its necessary accessories is illustrated the pressure gauge and safety valve and with their use the application of absolute pressure and gauge pressure. It affords examples of the various forms of cock and valves that are universally used for the control of water, steam and gas, and provides means for the study of their mechanical construction and care. The feed-water pump furnishes an illustration of a form of steam engine combined with a water pump and illustrated in the difficulty of pumping hot water—

Digitized by Google

the principle of low-pressure vaporization. If the heating system happens to be of the vacuum type, the opportunities for the study of the properties of steam are greatly increased. Once there is made an acquaintance with the heating plant and the student is required to report on the various functions of the accessories and the working principle of the entire plant, the subject becomes at once alive with interest.

Temperature regulation has come to be a recognized part of every form of a school heating system. Temperature regulators are made in two general types, the electric thermostat and the pneumatic thermostat. Each has its particular field of usefulness. The electric thermostat is the type best suited for the household. It is manufactured under various patents, each of which accomplished the same functions in some difference of manner. A general knowledge of its construction and mode of attachment to the furnace; a little instruction as to the limits of its usefulness, and the thermostat is the most faithful mechanical servant. Without this information it may do exactly the reverse of its desired function and require the services of an expert.

The pneumatic thermostat is the heat regulator that is used in large buildings when each room is to be separately controlled. Its mechanism is quite different from the electric type but its principles and operation are no more difficult to conprehend.

The temperature of school rooms is today very generally controlled by pneumatic regulators. Such a system provides, not only an illustration of heat regulating apparatus but shows the possibilities of compressed air as a means of transmitting work and power. It furnishes examples of motor valves both for radiators and for warm air registers by means of which a uniform temperature is maintained through thermostat control.

Every enterprising householder desires the advantages of running water in his home. It is today possible to provide a form of water supply under any condition of habitation. It may be power operated, and entirely automatic in its action; or it may be simple force pump and tank. The market provides facilities to suit any condition of operation. The ones interested may select among many forms of machinery, suited to the condition of use. It is a question of intelligent application of ready made things that are best suited for a desired purpose. Water supply, in connection with sewage disposal, is the most important —except heating—of all problems of house building.

Digitized by Google

Water has to do with every domestic service, it enters into everything connected with life. On its purity depends the health of the family and its convenient distribution contributed to the contentment of each of its members. Unlimited hot water is an unlimited blessing. Water and its use is certainly worthy of more attention than has been given as to its quality and the machinery required in domestic service.

While city schools do not furnish in their water fixtures examples of domestic water supply, they do provide all of the fixtures, valves, cocks and other appliances used in domestic water distribution. Many consolidated schools are provided with examples of perfect domestic water supply plants. All such buildings furnish means for the study of plumbing systems.

It is not expected that the future householder is to become a plumber nor a sanitary engineer but the most superficial acquaintance with the mechanics of water supply apparatus will be a very helpful guide to the builder of a home, and a slight knowledge of the general qualities of water, its purification, its softening and the means of guarding it from pollution is well worthy of more than passing attention. It is certainly worth while to know the various systems of domestic water supply that are used in private plants; the method of safe-guarding a good well from surface pollution, and the present day devices for softening water.

In the study of mechanics, power generation should have a place at least as instructive as a manufacturer's catalog. The present-day small electric generator has made possible the utilization of power of small streams that heretofore could not be made available; the hydraulic ram does most excellent service as a pumping engine in the neighborhood of a suitable stream and its use in connection with the pressure tanks makes an admirable as well as an inexpensive system of water supply. Apparatus of this kind may be obtained ready for installation. In many instances natural water power sites, suitable in size for a family, may be installed at nominal expense. It is this practical feature that should be brought to the attention of learners. While school buildings provide examples of this type of power generation they may be discussed in connection with the engines that form a part of the mechanical equipment.

Sewage disposal has come to be so generally recognized as to require no argument in its favor. The type of private sewage disposal plant for a definite purpose is today only the necessary

Digitized by Google

mechanical arrangement to suit the place of its installation. The septic tank, either of itself or in combination with an anaerobic filter is successfully used as a means of a private sewage disposal under almost any topographical conditions. It is successfully used even in flat areas where effluent must be taken up entirely by the earth in the immediate vicinity. The principles of the septic tank, its construction and operation, are well within the range of the average intelligence, and may with profit be taught in connection with natural science. It ought not be necessary that people who are supposed to be scientifically educated should be required to ask as to the possibility of disposing of sewage.

Many consolidated schools dispose of their sewage through such plants. In any case the school supplies examples of plumbing that is a part of sewage disposal system and provides material for the study of a great variety of fittings, pipings, fixtures, traps, vents, flush tanks, closet seats, schemes of plumbing and all else that has to do with its sewage up to the means of final disposal. These may all be examined in detail and under working conditions.

The ever increasing cost of fuel—which has now reached a point sufficiently high to be viewed with alarm—shows no tendency to decrease. What does the average person know of fuel values? Even in favored localities where fuel is plentiful the price is sufficiently high to cause concern, and in the more remote localities in a cold climate the cost of heat is viewed with the gravest consideration.

So little attention has been given to relative fuel values that practically none but engineers are acquainted with the measurement of heat. Even scientists who are accustomed to heat calculations, in chemistry, physics, and other branches, are lost when quantity of heat is mentioned in B. t. u's, the common standard of its measurement. All contracts for fuel in the United States are based on the British thermal unit. All heating values of gases, fuel oils, and other forms of heat generators are rated on the same commercial basis. The law of this state says that, "coal-gas shall have a heating value of 600 B. t. u.'s, per cubic foot," and most people have not the remotest idea of its meaning. It is remarkably strange that every science, even home economics, expresses heat in calories and all industry bases fuel values in British thermal units.

It is of little consequence which is the better measure; common

Digitized by Google

custom is in favor of the established unit and should be used until custom changes. The point in question is this, when fuel is bought at the present price, what kind gives the greatest quantity of heat for a dollar? Where fuel-gas sells for a high price, is coal at the prevailing price a more economical fuel? Which gives the greater quantity of heat for the price, coal or gasoline? Kerosene or coal gas?

The heating value of coals is influenced very largely by the moisture and ash that are present. These factors may be readily determined without the apparatus of a scientific laboratory. Many school heating plants keep a regular log of the rate of evaporation in pounds of water evaporated per pound of coal burned. Much may be learned from an intelligent fireman as to the value of fuel, the quantity of fuel required to heat the building, the method of firing, the type of fire to produce the best results and the general information to be derived from acquaintance with heat generating apparatus. Fuel values are based on factors that are readily determined and not difficult of comprehension, their calculations are simple arithmetic. Coal is being sold by thousands of tons, at unheard-of prices, and the buyers take what is sent because the people do not know the heat value of fuel. In many cases coal sells today at $10 to $12 per ton which may and often does contain as high as 25 per cent of water and ash, a very high price for non-combustible material aside from the loss of heat contained in good coal.

The ventilation of houses is best understood from the investigation of the effects produced by the ventilation engineer. In his discussion, Mr. Lewis refers to the practice of ventilation as an art but much that has to do with ventilation is science. The scientific principles that are applied in ventilation should be made the subject of systematic study. The measurement of air, and its physical properties are effected by heat and moisture. The introduction and exit of air from inclosed spaces both by gravitational and by mechanical means all reach their highest perfection in school buildings. All these are topics that are touched upon in physics but usually they are not presented as actual working problems. The measurement of the air that enters this room through the ventilation system may become a problem of rare interest as well as a means of fixing upon the student's mind the quantity of air that is taken as a ventilation standard. Atmospheric humidity may just as well become a real problem where relative humidity and absolute humidity are

Digitized by Google

not mere physical terms but features of air conditioning. A knowledge of such apparatus as the Hygrodeik, with which humidity is determined mechanically from reading the wet-bulb and dry-bulb thermometers, as well as the Weather Bureau Hygrometer with a humidity table, contributes much toward an understanding of atmospheric conditions. The process of air humidification, as affected by the mechanical method of ventilation, is one of the most instructive means of explaining absolute humidity.

In his opening paragraph, Mr. Lewis said: "The art of ventilation has received much study—and there has developed a general practice concerning fundamental principles which should not be lost sight of." The art of ventilation applies most in this case to large buildings where mechanical means can be used to produce air in any desired quantity.

Aside from the general principles—that are not difficult to comprehend—the practice of ventilation is the mechanism used by engineers in ventilation systems. It should be the business of teachers to know the simple principles used in such plants as may be available. It is evident that there are differences of opinion among those who are best informed as to the most efficient practice in applying the principles that are fundamental. The teachers' business is to know to what extent these fundamental principles are applied. In case of different systems, as air-conditioning plants, the teachers should be in a position to point out the object each is intended to attain and in some degree to apply such tests in determining their efficiency.

The use of the anemometer in measuring the air supplied to a school room is one that always arouses student interest and leads to discussions that are most profitable.

The electric fixtures of a school building ought to supply the commercial elements of electricity that are not contained in textbooks. At least one section of each school building should be so wired that the system of distribution will be exposed to view. The switch-board, which in most school buildings is sacred, and to be approached only by the man in charge, is a thing full of valuable information. It expresses the various circuits of the buildings, the reason for which requires explanation. The switches, fuses, and above all, the meter are features of electric practice that deserve close attention.

The modern school house possesses, of course, a complete system of electric wiring, for lighting, for bell system, and for the

Digitized by Google

program clock and frequently inter-communicating telephones, often generators, motors, transformers or motor generators. Each of these is in itself a course of study. The watt-meter should be a regular part of the physics laboratory. All bills for electricity should be checked by the students. Few modern schools are without a storage battery, the daily performance of which is of the greatest interest and value to learners. Its care, charging and maintenance should be common knowledge. The commercial application of electrical appliances is that part of the subject which in schools often receives scant attention. A duplicate of each receptacle, branch, block, cutout, switch, circuit, breaker or other fixture is each worthy of the closest inspection and consideration. The office of each piece may well be a part of the student's report with an explanation of the part it intended to perform, likewise each heater, light, motor, generator, transformer or battery may well receive attention as to general conditions of operation. It is not so much of im-importance to know the chemistry of a storage battery as to know how it is charged. These in schools should be a part of each student's course to inspect, analyze, to care for or to operate for a certain time, under the person in charge. If it is the janitor's business to care for the clock system, the janitor may become an instructor to explain his method of caring for the necessary apparatus.

Each part of the school equipment may become a part of the teaching apparatus with each attendant an instructor to the extent of his duties, each student to receive as much time and attention as circumstances will permit.

No human being can be expected to know intimately all that is applied in scientific nature in a modern school building. The director of such a course should then summon to his aid those who are best equipped to explain these matters. The student should report in his notebook as much as possible of the things presented. The important features of this subject is to acquire a general understanding of the subjects presented, then should occasion demand an intimate knowledge of any feature, he will have a foundation on which to build. More than this cannot be expected in any but a technical school.

GYPSUM IN 1919.

According to a preliminary estimate by the United States Geological Survey, Department of the Interior, 2,451,000 short tons of gypsum, valued at $16,000,000, were sold in 1919. This is an increase of 393,985 tons and of $4,529,146 compared with the sales in 1918.

Digitized by Google

THE PROJECT AS A METHOD OF TEACHING.

By Rolland M. Stewart.
Cornell University, Ithaca, N. Y.

I. Introductory Statement.

The project as a method of teaching implies that the teaching units provided for instruction purposes grow out of the use of projects. It does not imply, however, that teaching by use of projects precludes or excludes the use of other methods. Teaching by projects is a phrase not uniformly interpreted; in fact, there are many types of interpretation and of usage. Among these varying usages of the expression two important conceptions seem to have been derived:

1. To regard the project, whatever it is, as fundamental or basal in any teaching exercise, that is, it becomes the central and controlling means of carrying on units of instruction.

2. To regard the project as supplementary or applicative in nature, that is, it becomes the means of making specific application of principles supposed to be known whether that knowledge comes by way of memory or by way of reason.

In either case, the project is a means of vitalizing instruction. It is dynamic, impelling toward a completed unity of activity which the mind conceives. Whichever of the above conceptions of the project is accepted, self-activity is paramount; that is, first-hand experience in a real life situation, where the elements of the activity appear in their natural setting, is imperative. If not all types, certainly vocational types of education would demand this kind of first-hand experience.

II. What is a Project?

As indicated above, there are many varieties of interpretation of the meaning of project. Like many new terms, it has been used frequently with little discrimination; it has been identified: (1) With problem; or (2) with laboratory exercise, as in the application of the principles of physics to the mechanics of the phonograph; or (3) with the intellectual problem that is peculiarly knotty; or (4) with a series of routine activities, such as answering the telephone, reading a telegram, interviewing a senator; glancing at the morning paper, called a day's project; or (5) with ordinary attempts to accomplish a purpose.

The commonly accepted psychological interpretation presents the project as a purposeful act. This notion taken alone is inadequate since it suggests that the term project is identical

(Abstract of an address by Professor Rolland M. Stewart before the annual Conference of Junior Extension Leaders, held at Cornell University, March 16, 1920.)

Digitized by Google

with that of problem, or purpose. This statement seems to ignore the sociological character of the project, thus limiting its scope as a method of teaching and really making the use of the term superfluous. The project as conceived in agriculture implies the purposeful act, but also puts emphasis upon the typical forms which the purposeful act has made objective and which the purposeful act continues to hold objective, since it represents a complete cycle of relationships. Subsequent considerations will make this criticism clearer.

May we regard then as a project any enterprise, however large or small, provided that in such enterprise no elements essential to its completeness, as it does or would exist in real life, are omitted. For school purpose then a home project is a unit of activity whose form and purpose are either identical or fundamentally similar to those of a like unit of activity in its natural setting.

III. What are the Standards of Teaching?

Before we can say what educational value the project presents in teaching method, we must state the principles by which the project method is to be measured. Skill in teaching demands at least six points:

1. Teaching should motivate the pupils; that is, the teaching must carry aims, purposes and problems which are accepted by the pupils as worth while.

2. The teaching must provide for pupil initiative; that is, opportunity for self expression should be conspicuous.

3. The teaching should provide also for pupil judgment; that is, the plan must permit choices on the part of pupil with reference to the purposes accepted, and with reference to the steps taken toward the realization of such purposes.

4. The teaching should provide for organization of thought on the part of the pupil; that is, responsibility for marshalling the facts in the direction of the purpose to be realized is primarily the pupil's.

5. Teaching must provide opportunity for use and application of the principles arrived at in the teaching exercise; that is, principles must be applied in order to be comprehended.

6. Teaching is essentially a program of discipline; that is, whatever may be the teaching exercise, it should train the pupils to think.

IV. How Does the Project Meet These Requirements?

1. *It furnishes a basis of motive and purpose.* The project

Digitized by Google

demands first of all self-activity. The word implies constructive self-activity. Whatever furnishes a basis of worth-while activity motivates and interests. The strong appeal which the project makes to boys and girls may be explained partially as follows:

(1) Nature has an abundance of energy to expend, which she releases most readily along race-old paths. The project activities furnish a strong appeal to these native tendencies, because of their multiple contacts in experience with the concrete and tangible things which are to be controlled and manipulated. Particularly at spring time there is a ready release of energy for these activities of the out-of-doors. The value of these channels of expression in motivating work will not be denied. The question may be raised whether the lessening of available energy by work and the appeals of new things may not reduce materially the peculiar educative value of the project as a method of teaching. The answer is that the project form of study would still remain significant.

(2) Competition and cooperation appear to protect the project against any such possible waning interest. Frequently these factors are the principal basis of completing a project. Nature has so endowed youth that even after an activity may seem to lose its value for itself, it is still pursued because of the social appeal which the activity implies. In other words, competition and cooperation are tendencies that can release energy even when it almost seems to be lacking. The project is an enterprise with such a social setting that the pupil may complete his work for sake of social approval or sanction. It is not necessary, however, to assume that native interest has entirely waned since the project is furnishing constant change of experience and new relationships to control.

(3) Promise of economic return adds strength to the motive power of the project. Many children leave school for economic returns. The project becomes a means of giving promise of economic return without the necessity of breaking with the school; at least it furnishes an opportunity for independent managerial activity which appeals to adolescent life.

2. *It provides for individual initiative.* One of the principal arguments for the project is the opportunity it furnishes for the expression of individual initiative. This position is tenable since:

(1) The project reflects the pupil's own desires. It is placed upon the pupil to select the project, helped by the counsel of the parent and teacher when needed to prevent serious mistakes.

Digitized by Google

(2) It recognizes individual differences. As children pass up from grade to grade the differences become more marked and therefore more recognizable. The project being an individual undertaking is selected therefore on the basis of the individuality of the pupil who is to manage and execute the work.

(3) The character of the project demands not alone an initial spurt, but a continuous expression of initiative; that is, it is an activity that demands constant direction by the pupil however well it may have been launched.

(4) The pupil is responsible for the project from the time that the selection is made until the final report is completed and accepted. This type of teaching bids fair to correct an evil in modern education which is growing with the accentuated emphasis upon expert knowledge, namely, dependence upon subject-matter experts for all responsibility in interpreting facts and principles.

3. *It provides for individual judgment.* No great amount of initiative will be expected to appear in a pupil if no credence is given to his judgment. Judgment develops in an individual only as he accepts opportunities for making choices. The project furnishes a constant exercise and testing of judgment:

(1) In the first place, the selection of a proper project is a real challenge to the judgment. The teacher and parent may offer counsel; in fact, they may lend much aid, but among many possibilities the pupil is to make his own selection. His selection of a particular type of project in agriculture would demand cognizance of the community needs which the project was to serve, of the farm on which it was carried out, of the facilities of school and the teacher for training, of the parents who were to supply equipment and counsel, and of many other factors which would be involved.

(2) A project which runs through a period of weeks and months involves the continuous use of judgment after the selection has been made. If he selects a poultry project, he must from time to time answer such questions as: What breed of chickens shall I handle? What incubator shall I use? When shall I start the incubator? as well as a host of other questions which continue to appear throughout the cycle of activity.

(3) The judgments are stated. A judgment that is stated finally in a social medium, whether that medium is a group of farmers, a class in school, or what not, becomes very significant educationally. Many judgments are made by pupils but be-

Digitized by Google

cause they are never checked they leave the judgment, after all, flabby and impotent. The decisions which the project boy or girl makes are always open for check by his fellows in the school and the community. In other words, the project furnishes tangible evidence of expressed judgments, which are checked formally in class work, informally in interested social groups.

4. *It supplies a real situation for the organization of thought on the part of the pupil.* Much, if not most, of our school work is broken up into fragments of study almost innumerable. This situation tends to break or lessen any demand for organization of thought on the part of the pupil, particularly since teaching is being done more and more by subject-matter experts.

With pressure for time in presenting this vast amount of culture materials, teachers tend to furnish pupils predigested educational pabulum; that is, teachers thinking that they can utilize more subject matter in this way, present their teaching material to the pupils in logical form, thereby developing in them an attitude of dependence and passive acceptance. This procedure gives little necessity for sustained attention. Quite in contrast with this, the project by virtue of the steps that are necessary to take in it, carries the pupil along from the more fundamental to the less fundamental or from the less fundamental to the more fundamental, giving him a rather definite and clear view of relationships involved. These relationships appearing in an actual enterprise become meaningful where abstract materials, however logical in presentation, would fail to secure response. The demand for the use of the imagination in project activity furnishes the most normal transition from thinking in the concrete to thinking in the abstract. The tangible connections are more stable because of the multiple associations that necessarily form in such an activity. The true basis of reasoning lies in the pupil's control of these tangible connections and not, as some try to imply, in the tangible things themselves. The pupil who might object to the logical outline of the teacher finds himself, together with the teacher, checked by the facts and principles that inhere in the concrete situations which the project involves. In the field of the abstract the differences of opinion may be so marked as to baffle the mind against any fruitful organization. The high school pupil might find genuine opportunity for organizing his mind in an attempt to follow selection through a cycle in animal breeding when an attempt at comprehending the theory of evolution would be

Digitized by Google

futile. The project provides an ideal setting for organizing first-hand experience and discovering its relationships in life.

5. *It implies fundamentally utility and application.* Teaching by means of the project begins in the thought of application. It is not a mere last step in instruction. It is rather not only the beginning and the end of instruction, but is its central purpose. Because utility and application are the central purpose of instruction, the four points already discussed are the more readily realized. Without the idea of utility and application, teaching becomes spurious and colorless. When the test of application is made to the project, the conception already stated—namely, that the project is basal and central in instruction, is fully substantiated; for the project that merely furnishes an opportunity for applying principles becomes incidental and loses much of its force as a means of controlling the factors of learning. It is in application that the two dominant conceptions of the project show their fundamental differences.

6. *The use of the project as a method of teaching implies a fundamental type of discipline.* The only true discipline is self-discipline, though agencies outside of one's self may point the way to self discipline. An activity that provides genuine problems, places responsibility upon the individual for initiative, judgment, and organization of thought, and is dominated by its useful and applicative connections is an activity, par excellence, for discipline. In fact, it exalts the idea of real discipline, the kind that gets its meaning in the organization of one's facts with reference to an activity that is felt worth while and for which responsibility is definitely placed and accepted. The organization of the project reinforces such an idea of discipline, a discipline which the situation demands, and not a discipline of outer compulsion. There are at least three types of disciplinary factors involved in project working.

(1) It is an activity, first of all, in a natural setting. The pupil must conform to nature. Teachers may be wrong, but nature must be taken as she is. To violate the laws of nature, is to invite a type of check that cannot be gainsaid.

(2) It is an activity in a social environment, where the group stimulates, where the group then praises and blames. To disappoint the upholders of the sanctions of society is to invite embarrassment and chagrin.

(3) It is an activity in an individual mind that is very sensitive to its own integrity. Because the mind must give outward

Digitized by Google

expression constantly in the execution of a project—an expression that is always checked socially—this integrity is safeguarded by intensive thought. To become conscious of a lack of mental integrity is to undermine one's self-respect.

V. *May the project do even more?* In addition to meeting the standards of teaching which we have imposed, the project may do even more in making instruction dynamic.

1. It gives the pupil acquaintance with a new field of activity from which he may gain mental content for (1) general culture, (2) educational guidance, and (3) vocational guidance.

2. Since it is experience in a natural setting, it furnishes a comprehensive vantage ground for evaluating tool subjects which so often have little motivating power. A tool is never so much valued as when need for it is upon us.

3. Since it is an experience in a natural setting, it opens up new fields for thought, problems that have never been attacked even by mature investigators. Opportunity for discovery is the greatest incentive for study. Not all of its value is lost even if it is only a rediscovery.

4. Since it recognizes individual differences as they are recognized in human society it is a basis of stimulating all classes of pupils. It not only sets minimum standards upon which the dull may fall, but opens a competitive field in establishing maximum standards for all, however bright. It may be graded to suit different classes and may be graded to suit individuals in the class. It can be based upon the level of activity for the less mature, upon approbation where group life would affect it, upon economic return where money becomes an important issue, and upon other factors when found operating. It furnishes a stable basis of controlling the individuals upon whom many and variable demands rest in our modern, more or less, entangled society.

5. Since it puts some emphasis upon economic return, it provides a suggestion for meeting the demand of high school boys and girls for remunerative employment during school days, and gives economic significance to educational activities. It emphasizes managerial ability which is akin to genuine learning.

6. It supplies immediate connections for educating parents. How much the public school contributes directly to the education of adults through the children no one can state; that the influence is tremendous no one will deny. Because of the nature of the home project activities, this contact is close and vital

Digitized by Google

and therefore it has additional force as an educative instrument through the more or less incidental modification of home practices that results. These values extend beyond the home to the whole community. The tangible expressions of pupils become stimuli to others. How many people in the neighborhood treat their potatoes for scab because some boy's project proved so successful!

7. Its by-products are many. Since it gives first-hand experience in a natural setting, many phases of this experience are not immediately useful in the enterprise; however, as already indicated, they supply raw materials for vitalizing all types of instruction. A visit of three days in Chicago gives food for thought connections in manifold ways for years. To capitalize such by-products for general educational ends harmonizes with all fundamental principles of education. The project is rich in illustrations for incidental education; for example, the boy who had a home garden as his project was seen lying prone intensely watching something in the earth. It was a strange insect with many legs. He caught it and took it to the "professor." Incidental to the project, it became a stimulus to intelligent activity, not only in the garden itself, but in the school and elsewhere. It is becoming more and more true, I think authorities agree, that the profits of the farm tend to correlate high with the efficient use of the by-products of the farm. The results of project teaching suggest that the same principle holds true here. The project becomes increasingly valuable to the extent that it gives educational significance to economic production and uses economic production to vitalize the processes of education, a series of give-and-take processes in a real life situation.

IS VENUS CLOUD COVERED?

Mr. Evershed has taken many photographs of the spectrum of Venus in recent years for the purpose (inter alia) of endeavoring to detect the Einstein shift and of testing his own hypothesis that the earth has an effect on the atmospheric circulation of the sun. In the course of this work he found, to his surprise, that a much longer exposure time was needed than was the case in photographing the spectrum of a cumulus cloud on which the sun was shining (Monthly Notices R. A. S., November). Mr. Evershed expected the time to be shorter, for the intensity of sunlight on Venus is 1.92 times as great as on the earth. Allowing for the absorption of Venus's atmos; here, he concludes that if Venus were covered with clouds similar to our cumulus clouds the exposed time would be less on the former than on the latter in the ratio of 1 to 1.3, whereas the contrary is the case. He concludes that the atmosphere of Venus is not cloud laden, but that its lower strata contain much dust in suspension, veiling the surface features. This conclusion is similar to that reached by Prof. Lowell from his observations at Flagstaff.

Digitized by Google

FREE FALL MACHINE; OR ACCELERATION APPARATUS FOR MEASURING "G": AND THE LAWS OF FALLING BODIES.

By I. Thornton Osmond,

Pennsylvania State College, Carlisle, Pa.

This apparatus is new in principle, construction, and operation; may be easily and cheaply made by any high school; and I have not patented it; it is free.

1. It gives notably good results. See at close of this article.

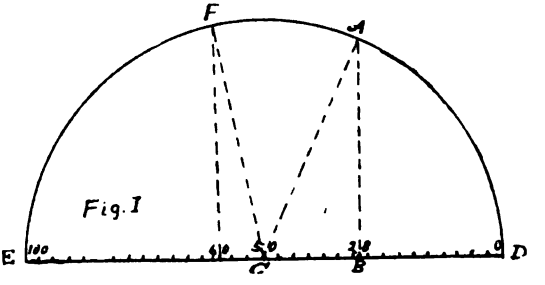
2. The construction is very simple—no delicate parts to get out of order.

3. The student's attention is not diverted and occupied by mechanisms, electro-magnets, motors, bells, etc.

4. *The body falls absolutely free* (except air friction); no counterpoises, nor pulleys, no sliding down rods or grooves with unknown amount of friction.

5. It brings to students, in a practical way, Simple Harmonic Motion, one of the most fundamental, universal, and important forms of physical action.

Principle of Construction and Operation.



If A, Fig. 1, moves with uniform velocity around the semi-circumference, DAE, 180°, the foot B of the perpendicular from A on the diameter will move with a Simple Harmonic Motion along DCE.

Let DCE be graduated into equal parts, say 100; and let t′ be the time in which A moves around DAE, 180°, say one second. In what time will B move from D to 28? To 60? Any point?

At 28 draw the perpendicular AB, and measure the angle DCA.

Angle DCA : 180° :: 1 second : t, the time required; t = 180° ÷ DCA.

In the same way the time required for B to move from D to 60 is Angle DCF : 180° :: 1 second : t; t = 180° ÷ DCF.

Digitized by Google

In general, in any Simple Harmonic Motion if the path and period, t′, are known, the time, t, occupied in moving to any point of the path is thus easily found.

Instead of A moving around the semicircumference and B moving along the diameter, let A and B be in a fixed line perpendicular to DE, and the semicircle move past the line BA in such manner that the same number of degrees of the semicircumference will pass this line in equal instants of time. Then DE will move past B with Simple Harmonic Motion, and the time, t, when any point of DE will pass the line AB will be found just as above.

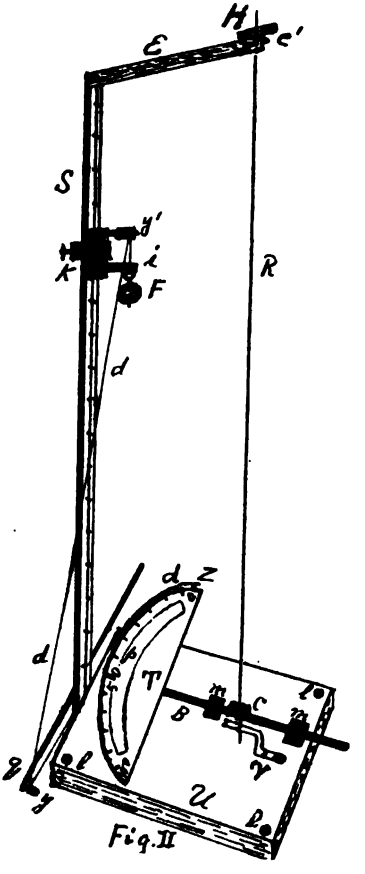


Fig. II

CONSTRUCTION.

S, standard, 2m±high, graduated line on front; E, cross arm; H, torsion head; and c′, clamp; R, steel rod, 200 cm±long, about 3mm diam.; B, cross bar clamped to R at c; T, segment

Digitized by Google

attached to B, with arc divided into equal parts, 100±; radius 30±cm; P, piece of thick soft paper, as blotting paper; F, body for falling, sharp point below; K, bracket movable along S; i, pin with vertical slot for thread, from rear, y′, small pulley or roller; y, small pulley or roller; d, d, d, thread passing from F through i over y^1 and y and attached to T at Z; q, bar sliding through S, to tighten thread, rotate T and produce torsion of R; v, metal strip with hole through which R passes loosely; m, m, masses movable along B to make the time of oscillation of T what is desired; l, l, l, leveling screws; U, base (may be of any form); material nearly all wood, except R and F, a 3/4 inch iron ball.

OPERATION.

Put K at any desired height on S, and by the leveling screws and plumb line make S vertical. Slightly loosen clamp C^i and by turning H bring the middle line of graduation on T exactly under the plumb, where F will fall from i. Tighten C^i very securely.

Suspend F, 3/4 inch iron ball, by a thread through i over y^i and y and attach the other end to T near the o of graduation. By the thread turn T so that o of graduation comes to the line on the front of S, the point vertically below i, where F will fall. Hold T in this position by the thread and adjustable rod q.

Burn off the thread: about opposite i.

Thus F begins to fall and T to move at the same instant.

Read carefully the distance from the bottom of F (when at i) to the top of T; and also the division on which F struck.

Find, also, the "damping" for the first swing of T, by bringing the o of graduation to the line on the front of S, releasing T and observing how much the highest graduation on T misses of coming to the line on S: a proportional part of this "damping" is to be added to the division on which F falls.

Gravity, "g" and laws of falling bodies from experiments: By the weights m, m, the time, t^i, of oscillation, a single swing of T, was made one second (this makes the calculations simpler than any other value of t^i); and the "damping" was found to be two divisions.

Four experiments gave the following:

	I.	II.	III.	IV.
Distances fallen	168.5 cm	137.3 cm	103.3 cm	71.3 cm
Divisions struck	61.75	53.85	41.80	31.45
(Add for "damping")	1.2	1.0	1.0	0.8
	62.95	54.85	42.80	32.25

Digitized by Google

To find the times of falling through these different distances we use the principle of Simple Harmonic Motion as explained above.

The work may be done by either of two methods, (a) Instrumental, (b) Trigonometric.

(a) Instrumental:

The drawing, Fig. III, should be quite large and very accurately made and used.

Draw DE, say 20 centimeters length, to represent the 100 equal divisions of the graduation on T: then each cm. is five divisions and two millimetres are one division. Draw the semicircumference DQE.

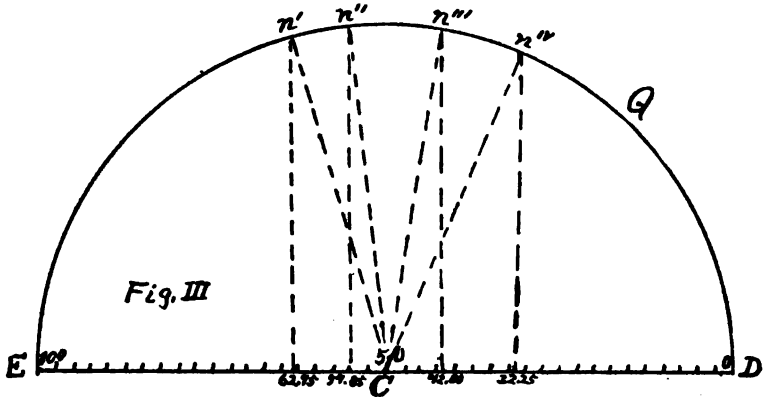


Fig. III

In Exp. I, the ball F struck on division 61.75, or adding 1.2 for "damping," 62.95. Draw the perpendicular from 62.95 to the semicircumference at n^i, and measure the angle DCn^i, 105°.9.

Then, the time of falling, t, is to the time of oscillation, t^i, as angle DCn^i is to 180°.

$t : t^i :: 105°.9 : 180°$, and t^i being 1 second, $t = 0.588$ second.

In the same way the time of falling in each experiment is found; as indicated in Fig. III, n^{ii}, n^{iii}, n^{iv}.

Put the distances fallen, the divisions struck, and the times of falling in a

TABLE.

Exp.	Distance fallen cm	Struck on Division	Corrected for Damping	t seconds	t^2 seconds	First second cm.	"g" cm.
I	168.5	61.75	62.95	0.588	0.3457	487.4	975.6
II	137.3	53.85	54.85	0.528	0.2775	494.7	989.9
III	103.0	41.80	42.80	0.454	0.2065	496.5	998.0
IV	71.3	31.45	32.25	0.383	0.1466	480.6	972.7

Digitized by Google

Means 489.8 cm, 984.0 cm.

A simple trial shows that the distances fallen are not proportional to the times of falling, but are proportional to the squares of the times.

Thus $168.5 : 137.3 : : 0.588^2 : 0.528^2 = 0.3457 : 0.2775$.

Square the times of falling and put the squares in the fifth column of the table.

LAW I.

In free fall, spaces fallen are proportional to the squares of the times of falling

$$S : S' : : t^2 : t'^2 \quad \ldots\ldots(1)$$

By Law I, find the space fallen in the first second:

168.5 cm : x cm : : 0.3457 sec. : 1^2 sec.; x = 487.4 cm from Exp. I.

137.3 cm : x cm : : 0.2775 sec. : 1^2 sec; x = 494.7 cm from Exp. II.

103.0 cm : x cm : : 0.2065 sec. : 1^2 sec.; x = 496.5 cm from Exp. III.

71.3 cm : x cm : : 0.1466 sec. : 1^2 sec.; x = 480.6 cm from Exp. IV.

The mean of the values of x from the four experiments is 489.8 cm [should be 490 and 1 or 2 tenths].

LAW II.

In free fall, a body falls 490 cm in the first second starting from rest.

By Law I, derived from our experiments, the distance fallen in two seconds is 2^2, or 4, times the space fallen in one second, which from our experiments is 489.8 cm (take it 490); 4x490 = 1960 cm.

In 3 seconds the space fallen is 3^2, or 9 times as far as in the first second; 9x490 = 4410 cm. In 4 seconds, 4^2, or 16, times the space fallen the first second; 16x490 = 7840 cm. And so on.

$$S = 490\, t^2 \quad \ldots\ldots(2)$$

In each successive second the body falls 980 cm farther than it fell during the preceding second, so we have

1. A freely falling body has Uniformly Accelerated Motion

2. Gravity, "g," is a force that acting for one second on a free body produces an acceleration of 980 cm per second

"g" = 980 cm per second per second.....(3)

Since by a uniform acceleration the velocity of a freely falling body is increased at the rate of 980 cm per second, we have

Digitized by Google

Law III.

In free fall, the velocity at any instant is 980 times the number of seconds.

$$V = 980t = gt \quad \ldots\ldots (4)$$

The experiments give $S = 490t^2$, and $g = 980$, or twice 490; so we may rewrite Eq. (2) as

$$S = 1/2\ gt^2$$

The three laws and the equations that we have found by our experiments are sufficient for the solution of all problems of freely falling bodies. Obviously they are also the laws and formulas of all Uniformly Accelerated Motion.

(6) Trigonometric Method:

Instead of making a drawing, like Fig. III, the time of falling may be found by use of a table of cosines. It should be a table giving the cosines for every minute of each degree, but briefer tables can be used fairly well by taking proportional parts.

Referring to Fig. III, it will be seen that the distance between the division struck by the falling body and the centre of the path, 50, is the cosine of the angle whose ratio to 180° is the same as the ratio of the time of falling to the time of oscillation of T. So, from a cosine table it is easy to find the time angle without drawing a figure.

Example. In experiment IV the body fell 71.3 cm and struck on division 31.45; adding 0.8 for "damping" makes it 32.25. Distance to centre, $50 - 32.25 = 17.75$. The ratio of this to the radius, $18.75 \div 50 = 0.3550$, the cosine of 69° 12′, or 69°.2.

69°2. : 180° : : t : 1 second; t = 0.384 sec., time of falling.

If the division struck is beyond the centre, 50, as in Experiment I, the angle found from cosine tables that go to only 90° will be the supplement of the time angle. Division struck 61.75, add 1.2 for damping, 62.95. $62.95 - 50 = 12.95$. $12.95 \div 50 = 0.2590$, the cosine of 75°. The time angle sought (DCn^i, Fig. III) is the supplement of this, 105°.

Values of "g", from 8 experiments, consecutive experiments, not selected by rejecting poor ones:

Exp.:	I	II	III	IV	V	VI	VII	VIII	Mean
"g" :	973.36,	992.86,	980.00,	985.90,	967.10,	963.90,	988.20,	980.96	: 979.03

This work was done with the first machine, which I made by hand with a few common tools.

Digitized by Google

COMMON EVIDENCES OF AIR PRESSURE.

By Stephen S. Visher,
Indiana University, Bloomington, Ind.

The atmosphere exerts a pressure of nearly fifteen pounds per square inch, or a ton to the square foot at sea level. It would seem likely that there should be many results of this considerable pressure. However so perfectly is life and nature adjusted to this pressure that there are very few evidences of the pressure alone. The downward pressure of the atmosphere is balanced by a like pressure in the opposite direction by air beneath or within most objects. Air pressure becomes evident to our senses only where there are local differences in the amount of air pressure. Where such differences occur, air rushes, or tries to rush, into the place of lesser pressure, and this movement or force is conspicuous.

In most texts dealing with the air, several evidences of air pressure are enumerated. Upon consideration, it will be recognized that practically all are not evidences of air pressure itself, but are results of differences of air pressure. Perhaps the only common evidence of air pressure not involving local differences in air pressure is the influence of air pressure upon the rate of evaporation and upon the boiling point. Though this influence is exceedingly common, in that it affects all common cooking greatly, it is not simple nor conspicuous, nor determinable without special equipment. It is due to the fact that the escape of molecules from the liquid is interfered with by collisions with the overlying molecules. The greater the air pressure, and hence the denser the air, the larger the prospects of collision and consequent return by rebound of the molecule which was leaving the liquid. Where the air pressure is slight, as at high altitudes, water boils at low temperatures. (With each rise of 550 feet, the boiling point is lowered about one degree F.) When a marked cyclonic low passes a point, the boiling is more than 3° F. lower than when a high (anticyclone) is over that point.

It may be worth while to list a considerable number of common results of local differences in air pressure (commonly called evidences of air pressure).

(1) Wind is air rushing from a place of greater air pressure towards one of lesser air pressure. Because of the influence of the rotation of the earth and of centrifugal force, the movement is not often direct. If it were direct, the differences of pressure would soon be equalized and the wind would soon die down.

Digitized by Google

(2) When two objects with flat surfaces, pieces of smooth plate glass, for example, are put together, they are hard to separate. The difficulty of separation is related to the partial vacuum which is created between the surfaces as they are first being forced apart.

(3) Cardboard milk-bottle covers are held down by the greater air pressure above them than below. The air originally below the cap is partly dissolved in the fresh, unaerated milk and a partial vacuum is created below the cap.

(4) After fruit, vegetables, or other substances which have been sealed into a can while hot have cooled, the can is often dented by the greater pressure of the outside air than of the inside air.

(5) A cork placed in the neck of a hot bottle is forced by the greater outside air pressure far into the neck as the contents of the bottle cool and contract.

(6) When hot tumblers, or other dishes, are inverted upon a smooth wet surface, and allowed to cool, they are often somewhat difficult to remove. If they are standing in a shallow layer of water when they cool, the water may be forced by the greater air pressure outside to enter the dish.

(7) The liquid in a liquid barometer is kept up by the pressure of the air upon the liquid in the cup into which the open end of the tube is immersed. At the closed end there is a vacuum. An aneroid barometer is essentially an air-tight box with one flexible side. When the pressure of the outside air is greater than that inside the box (or greater than that of a spring inside of the box if the box is not filled with air), the flexible side is depressed slightly. When the inward pressure of the atmosphere is less than the pressure outward of the contents of the box, the flexible side bulges out.

(8) Liquid rises in soda fountain straws and in similar straws when the air pressure on the liquid into which the tube is immersed is greater than that on the liquid near the end of the tube.

(9) The common self-filling fountain pen is filled as a result of the greater air pressure upon the ink in the bottle than upon the ink inside of the pen.

(10) Flow of a liquid along a siphon is started by creating a partial vacuum at the longer end of the bent tube. The liquid continues to flow, as long as liquid is available, because it cannot stop flowing without creating a vacuum where the liquid column breaks. The height to which the liquid can be raised in a siphon depends upon the amount of air pressure.

Digitized by Google

(11) Many automobiles have a vacuum gasoline feed. There is a hole in the cover of the gasoline tank through which the air enters and exerts its pressure. If this tiny hole is stopped up, the gasoline will not flow.

(12) All liquid containers which are emptied through a small hole must have another hole through which the air can enter. In other words, both bungholes of a barrel must be open; otherwise, the efforts of the outside air to enter the vacuum created by the escape of the liquid will soon prevent the flow of the liquid.

(13) The pus-cup, in common use in hospitals, is placed over boils after having been warmed over a flame. As the cup cools, the flesh is gradually forced by the outside air pressure to enter the cup a short distance and the pus is gently squeezed out into the cup. The cup is removed by pushing one finger under the edge of the cup and thus allowing the air to enter.

(14) The common valve pump operates because of air pressure. A stroke of the piston partially exhausts the air above the air-tight valve. Air pressure on the water in the well or cistern forces some of the water up past the valve. Priming is a means of making a leaking valve air-tight.

(15) The ascent of warm air, as in a chimney, is due to the difference in the pressure exerted by cold and by warm air. If not tightly confined, warm air exerts less pressure than cold air because warm molecules vibrate more and hence pack less closely than do cooler molecules. Thus there are fewer molecules per unit volume of warm air than of cold air, where other conditions are similar.

(16) The rapidity of ascent of a hydrogen-filled balloon varies with the air pressure, the cause of its ascent. The height to which it may ascend is likewise limited by air pressure. It cannot ascend to where the amount of pressure is nil. Therefore, it will always be impossible to send balloons to Mars, for example, as impossible as it will be for an aeroplane to ascend to where the air pressure is below a definite minimum.

(17) Part of the destructiveness of tornadoes is due to the slight air pressure in their vortexes. Many closed buildings are disrupted by the relatively greater outward pressure of the air within them.

(18) Thunder is largely due to the rush of hot air out from the path warmed by the lightning discharge, and later, after cooling has occurred, the rush back to fill the partial vacuum so created.

Digitized by Google

(19) The report following an explosion, such as when a gun is fired, is due chiefly to the rush of air and gases from the center of great pressure (the explosion).

(20) Tones from the pipe organ, and from other wind instruments are likewise made by the rush of air from a place of greater pressure to one of lesser pressure.

(21) All sound waves make themselves evident to us because they are variations in the amount of air pressure. The diaphragm of the ear is adjusted to a definite amount of air pressure. When more air presses upon it, it is indented, and the impulse is sent along the nerve.

(22) A fast moving train creates a partial vacuum under and behind it. Sometimes heavy mail bags thrown from the mail car near the front end of the train are carried beneath the train by air rushing into this partial vacuum.

(23) Racing automobiles have long "tails," so shaped that instead of a partial vacuum just behind the car, there are air currents which help push it ahead.

(24) It has been proven by investigations in aero-dynamics that an airplane is lifted not alone by normal impact due to the forward movement of the sloping plane against air, but also as a result of the partial vacuum created just above the sloping plane. For mono-planes, nearly ¾ of the total lifting is due to this effect. For biplanes this effect is slightly less important.

(25) Vacuum cleaners clean by means of the air which rushes into the partial vacuum developed by the pump. The greater the atmospheric pressure, the greater the suction power of the cleaner.

(26) The player piano, and many other similar mechanical devices are operated with the help of the atmospheric pressure. Air forces its way through the perforations in the paper to enter a partial vacuum created artificially within the instrument. As it enters, the hammer is released.

(27) Compressed air is used very extensively in modern industry. Its use depends upon the fact that the normal air pressure is relatively slight. The less the outside air pressure, the more efficient is the compressed air.

PEAT IN 1919.

According to a preliminary statement by the United States Geological Survey, Department of the Interior, 76,301 short tons of peat, valued at $860,841, were sold in 1919. This is a decrease of 30,960 tons and of $186,402 compared with the sales in 1918.

Digitized by Google

A PROBLEM AND ITS NUMERICAL SOLUTION.

By W. W. Sleater,

University of Michigan, Ann Arbor, Mich.

Not long ago when a somewhat unexpected assertion was made in a college physics class, a student inquired whether that result was practical or "only theoretical." That some ideas are practical, useful, and important, while others, though true enough, are theoretical, and therefore of no consequence, has always been a common conviction. No doubt such a distinction exists, but the conviction is objectionable when it is felt, if not precisely maintained, that a result is useless because it is theoretical. The same sort of comparison exists in the public mind between academic results and practical ones, a comparison having its perfect expression in the remark of Mr. Shaw that those who can, do, while those who can't, teach. No one who recognizes that teaching itself is doing will feel the sting of Mr. Shaw's irony. For others it is perhaps intended and by them no doubt deserved. It has, however, been generally supposed that an "academic" result savors of seclusion and perhaps of luxurious other-worldliness. Though the work of scientists in the war may have modified or partially removed that notion, it still lives, and it is not altogether groundless.

Such truth as there may be in the belief that academic conclusions are of negligible importance arises from the fact that the problems assigned and solved in school and college are always selected. They are carefully chosen, made up on purpose even, like chess problems, rather than taken at random from everyday experience. The rigor of the selection is very real to the teacher who supplements his textbook by outside examples. One hesitates to give to his class a problem he himself has not solved—he hesitates, at least, after having the not uncommon experience of being unable to answer his own question.

There is, of course, a legitimate reason for this selection. One does not assign to beginners in algebra a problem involving quadratics. But there is also a motive in the exclusion of problems which is at best doubtful. Students have been known to despair of the correctness of a solution because the answer does not "come out even." To conserve their time, and to keep his pupils in a comfortable and hopeful frame of mind a teacher may exercise more than paternal vigilance over the tasks assigned. The process of selection may exclude the common and so to speak unexpurgated questions which arise

Digitized by Google

in the world outside of school, and in which, of course, the likelihood of getting integral numbers as results is extremely small. This kind of exclusiveness is responsible for part of the unwelcome significance of "theoretical" and "academic."

A boy must not be discouraged, of course. But complete shielding either in home or school may have unfortunate results. It may, and no doubt often does, permit an unwarranted confidence which the young man has neither promise nor performance to justify. Or it may, in a boy conscious of his own limitations, produce a damaging timidity and self-distrust.

If the repertoire of methods by which we attack our problems could be extended, and their somewhat rigid limitations be removed we might perhaps be more hospitable in receiving questions. If we were spared the necessity of refusing to try problems and would agree so to speak, to meet all comers, the reproach of being academic in so far as it is a reproach might in a measure disappear. It is in the hope of encouraging this kind of hospitality that the following problem is presented. Neither the problem nor the nature of the solution is new, but they may serve to recall unused resources, and to encourage their application in other fields.

It is of course well known, but it is perhaps too seldom taught, that a numerical solution of any sort of equation can be made by trial. Moreover, except in rare cases, or specially selected ones, the root of an equation is obtained only approximately, being carried out only as far as necessity requires, even when the general solution is obtained. Now, although a literal solution of an equation cannot be found or is too hard to find, the numerical value of the unknown may be obtained by trial, and with as great precision as occasion demands. To illustrate, suppose

$$x^2+3x-8=0.$$

Solved in the ordinary way, the value of x is $-3/2 \pm 1/2\sqrt{41}$, or, *to five decimal places*, $x = 1.70158$ or -4.70158. A boy completely ignorant of quadratics might obtain this result and with no great amount of labor. It will not be necessary to go through with this problem the steps in the solution by trial. The third number tried after 1 and 2 gave $x^2+3x = 8.00005$. It may be remarked, however, that, although in this case the solution by trial to five decimal places is more work than the ordinary method, the difference might be relatively less if five more significant figures were required.

Now, the object of this paper may still be obscure, and its

Digitized by Google

readers are perhaps objecting to the project of solving quadratic equations by arithmetic, and they may be wishing to remind the author that it is trouble enough to teach boys what textbooks and principals require. No one knows this better than the author himself and his purpose may be specifically stated again. In the face of many problems which quite naturally arise we are in the position of a beginner in algebra confronted with the necessity of obtaining the value of x from $x^2+3x-8 = 0$. We may not know how to write out a general solution. But we can obtain a numerical root with as great precision as the nature of the case requires.

The particular problem which I wish to state and at least in outline to solve is as follows:

A bar magnet, pole strength 100 c. g. s. units and 20 cms long is placed at right angles to a uniform magnetic field in which H = 0.19 gauss. Locate the neutral points, that is, find the points at which the resultant field is zero. The magnet and field are disposed as in Fig. 1.

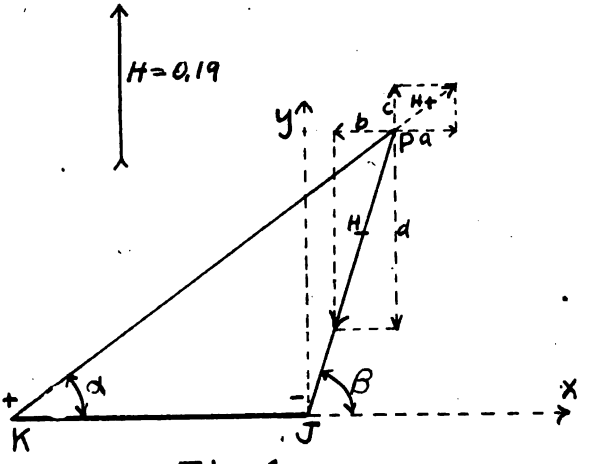


Fig 1.

Evidently the neutral points lie in the plane determined by H and the magnet. Also, at the neutral point, the two components of field, due to the two poles respectively, which are parallel to the bar are equal and opposite. The two components perpendicular to the bar must differ by 0.19. In Fig. 1, KJ is the magnet, H_+ and H_- the two fields at P = (x,y), a, b, c, and d the field components parallel to the x and y-axes, and H is the original field equal to 0.19 gauss. Then by the conditions of the problem

Digitized by Google

$$\text{A}\begin{cases} a = b \\ d - c = 0.19. \end{cases}$$

From these equations we must find x and y, and it is first necessary to express a, b, c, and d, in these terms. Evidently $H_- = 100/(x^2+y^2)$, $H_+ = 100/[(x+20)^2+y^2]$, so that

$$a = H_+ \cos\alpha = \frac{100}{(x+20)^2+y^2} \cdot \times \frac{x+20}{\sqrt{(x+20)^2+y^2}}$$

$$= \frac{100(x+20)}{[(x+20)^2+y^2]^{\frac{3}{2}}}$$

$$b = H_- \cos\beta = 100/(x^2+y^2)^{\frac{3}{2}} \cdot x/(\sqrt{x^2+y^2}) = 100x/(x^2+y^2)^{\frac{3}{2}}$$

$$c = H_+ \sin\alpha = \frac{100y}{[(x+20)^2+y^2]^{\frac{3}{2}}}$$

$d = H_- \sin\beta = 100y/(x^2+y^2)^{\frac{3}{2}}$. Therefore equations (A) become

$$\text{(b)} \quad \frac{100y}{(x^2+y^2)^{\frac{3}{2}}} - \frac{100y}{[(x+20)^2+y^2]^{\frac{3}{2}}} = 0.19$$

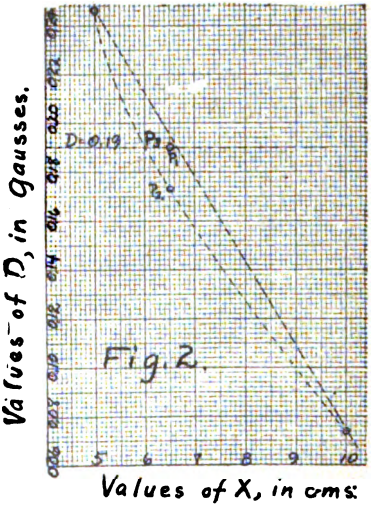
$$\text{(c)} \quad \frac{x}{(x^2 \times y^2)^{\frac{3}{2}}} = \frac{x+20}{[(x+20)^2+y^2]^{\frac{3}{2}}},$$

which give as roots the values of x and y locating the points we wish to find.

These equations may be so manipulated that x is expressed in terms of y by a cubic equation. Without attempting such a solution, the results may be obtained as follows: Assign arbitrarily a value to x, find the value of y from (c) and substitute these numbers in (b). The numerical value of the difference representing the first member of (b) will be called D, and D should equal 0.19. The problem has now become a matter of economy. The single equations arising in the process are pure quadratics, a circumstance accidentally favorable, and the actual labor, if logarithms are used, is not great. It must, however, be reduced to a minimum. Here a graphical method is applicable, and it is to suggest that method that the problem is undertaken. Values of x, first those arbitrarily chosen, are plotted as abscissas, and values of D as ordinates. Then as soon as two points are located a first approximation to the root, something more than a guess,

Digitized by Google

becomes possible. It will be the abscissa of the point in which the horizontal line through $D = 0.19$ intersects the straight line through the two points first located. Fig. 2 shows this point as near P_1. The straight line is located by using $x = 10$ and $x = 5$, from which $D = 0.074$, and $D = 0.246$ respectively. Now, using $x = 6.5$, the abscissa of P_1, $D = 0.1735$.



The new point is P_2, and it is now possible to correct the straight line first employed. A smooth curve through the original points and P_2 suggests $x = 6$, and this gives $D = 0.18975$. It may now be observed that as the range along our axes involved in the approximations becomes smaller the curve may with smaller error be considered a straight line, and desirable changes in x may be computed by direct proportion. In Fig. 2, P_3 shows the point whose abscissa is 6, and by applying the proportion as suggested, using P_3 and P_2, it is found desirable to try $x = 5.9907$. This gives $D = 0.19020$. In Fig. 3, P_1 and P_2 are points whose abscissas are 6 and 5.9907 and the straight line, or a direct proportion, gives

$$x = 5.9948, y = 18.6996.$$

These values are no doubt correct as far as they go. They could moreover have been carried somewhat further if the approximations immediately preceding had contained more significant figures. It is plain that another proportion would carry the result beyond the reach of any ordinary logarithm tables. The problem is now solved.

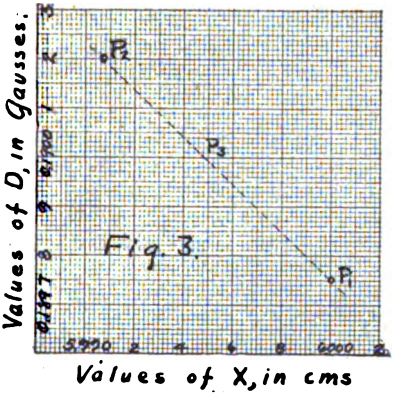
It is interesting to note that equations (b) and (c) could be

Digitized by Google

obtained perhaps more easily in another way. By first writing an expression for the potential at P, we should have

$$V_p = \frac{100}{\sqrt{(x+20)^2+y^2}} - \frac{100}{\sqrt{x^2+y^2}}$$

If now we form $-\frac{\gamma v}{\gamma x}$ and $-\frac{\gamma v}{\gamma y}$, the partial derivations of V with respect to x and to y at the point in question, we obtain the values, as in (b) and (c), of the several components of the field. This is an example of the physical meaning of a partial derivative and of the usefulness of partial differentiation.



It may be remarked now, if any readers have followed thus far, that the necessity of knowing the position of the neutral points near a bar magnet is not extremely pressing, that the problem chosen to exemplify a practical method is in fact somewhat academic. It will be admitted, however, that the particular example chosen is not essential to the purpose of the paper. Not long ago, in the course of some work done for the manufacturers of certain very useful kinds of glass, it became necessary to find the absorption and reflection coefficients of particular glasses for various wave-lengths in the infra-red spectrum. It was found that by comparing the intensities of the radiation at the particular wave length in the spectrum of a Nernst glower, first when a thick piece of glass screened the glower, second when a thin piece replaced the thick one, and third where neither was interposed in the beam, it was possible to separate the effects of reflection and absorption, to find the absolute losses of energy due to each, and to calculate the coefficients required. This required the solution at each wave length involved of an exponential equation. It was satisfactorily accomplished by the method above set forth.

Digitized by Google

Finally, it must not be urged against the pertinence of the suggestions of this paper that the methods of trial lack the elegance and generality characteristic of genuine mathematical thought. This presentation is made in behalf of practical results, so-called, and elegance and generality are sometimes or to some people matters of academic importance only. At any rate a boy may afford to extend his command over the difficulties likely to confront him and his teachers may not be unwilling to strengthen the foundations of his competent resourcefulness and conscious power.

NATIONAL RESEARCH COUNCIL.

The National Research Council, a cooperative organization of leading scientific and technical men of the country for the promotion of scientific research and the application and dissemination of scientific knowledge for the benefit of the national welfare, has elected the following officers for the year beginning July 1, 1920: Chairman, H. A. Bumstead, professor of physics and director of the Sloane physical laboratory, Yale University; First Vice-Chairman, C. D. Walcott, president of the National Academy of Sciences and Secretary of the Smithsonian Institution; Second Vice-Chairman, Gano Dunn, president of the J. G. White Engineering Corporation, New York; Third Vice-Chairman, R. A. Millikan, professor of physics, University of Chicago; permanent secretary, Vernon Kellogg, professor of biology, Stanford University; Treasurer, F. L. Ransome, treasurer of the National Academy of Sciences.

The Council was organized in 1916 under the auspices of the National Academy of Sciences to mobilize the scientific resources of America for work on war problems, and reorganized in 1918 by an executive ord r of the President on a permanent peace-time basis. Although cooperating with various government scientific bureaus it is not controlled or supported by the government. It has recently received an endowment of $5,000,000 from the Carnegie Corporation, part of which is to be expended for the erection of a suitable building in Washington for the joint use of the Council and the National Academy of Sciences. Other gifts have been made to it for the carrying out of specific scientific researches under its direction.

"EXPLOSIVE DUSTS" FILM ISSUED.

Why dust is dangerous is shown conclusively in a one-reel motion picture, "Explosive Dusts," recently issued by the United States Department of Agriculture, in cooperation with the United States Grain Corporation.

The old two-reel picture is being retained for the use of workers in the Bureau of Chemistry. The new one-reeler is especially designed for showing in high schools and other scholastic institutions, as well as before grain and milling men, fire prevention and insurance associations, and others directly interested in the subject.

Requests for the loan of the film should be made through some field worker of the Department of Agriculture, or they may be sent directly to the department. Arrangements also have been made enabling outside persons and institutions to buy prints of the film at the cost of manufacture.

Digitized by Google

THE USE OF CHARTS FOR PROSE PROBLEMS.

By Jos. A. Nyberg,
Hyde Park High School, Chicago.

In a previous paper[1] a method of solving time, rate, and distance problems by using charts on diagrams was discussed. The present paper considers how charts may be applied to the solution of some other prose problems. Although the method can not be used for all problems it is useful for beginners, particularly those who do not know where and how to attack a problem.

The "age" problem is so simple that it is used during the first months of algebra. Typical of it is: A father is five times as old as his son; two years hence he will be four times as old. Find the age of each now. The chart is but a concise tabulation of the given information:

	1920	1922
father	$5x$	$5x+2$
son	x	$x+2$

The explanation given to the class for such a problem would be: Two people are always spoken of, and we enter their names to the left of the chart; also, two distinct dates are always mentioned and we enter their corresponding years at the top of the two columns. To make everything as concrete as possible, I use 1920 instead of the words *now* or *at present*. Instead of 1922, we could write $1920+2$. The most important idea to impress on their minds is that the entries in the second column (under 1922) should be made without consulting the book. The book is unnecessary because if we know a person's age now, we can without algebra predict his age at any future year. The entries are made by adding or subtracting from the first column a certain number—in fact the same number that obtained 1922 from 1920. In my less serious moments I tell the class that, having made the entries under 1920, my text should close automatically and, like some safes, can not be opened until I have filled the second column from my head. The equation is next obtained by relating the last two entries in the chart. There is nearly always some pupil in the class who will want to enter $4(x+2)$ in the chart in place of $5x+2$. While he could of course derive the same equation in spite of such an entry, his method of derivation would be more difficult for the majority of the class to

[1] School Science and Mathematics, June 1920.

Digitized by Google

understand because his method can not be reduced to the rules given later.

The remaining illustrations will involve charts having three columns, and the "age" problem is a splendid introduction to them. Representative of the "coin" problem is: A man has two more nickels than dimes, and twice as many quarters as nickels. If he has \$4.35 how many of each kind of coins has he? The complete chart appear thuss:

	How many	Value of 1	Total value
Nickels	$x+2$	5	$5(x+2)$
Dimes	x	10	$10x$
Quarters	$2(x+2)$	25	$50(x+2)$

Again we note that the equation is derived from the last entries.

A variation of the above is the flower problem: A florist sold some roses at 25c each, three times as many tulips at 15c each, and twice as many carnations as tulips at 10c each. If he received \$45.50 how many of each did he sell? The chart would be similar to the preceding, and the columns would have the same headings. When working this problem I always point out to the class the similarity between the chart and the order pad of a grocery clerk which may, for example, read:

2 doz	eggs	80	1	60
3 doz	oranges	75	2	25

The similarity is evident. The algebra has merely interchanged the first two columns, stating the items first and then the quantity. And this change, we might note, is in favor of algebra, for actually the shopper decides first on what to buy and next on the amount.

The reader will have noticed that in using these charts, the pupil can follow certain general rules[2] (the second may appear ungrammatical in statement, but it places the emphasis where it belongs):

1. Write down what the problem talks about; for example, a father and son, nickel, dimes, etc., tulips and carnations, etc.

2. Whatever the problem asks for, fill that column first—with x and the various quantities of x.

3. The last[3] of the three columns must be filled from your head, not from any information in the problem.

Digitized by Google

4. The entries in the column filled by rule three, and any unused information are then used to make the equation.

Various types of problems will of course require various headings for the columns; and when such a new problem arises, the class should work out for itself the headings. One column will always be devoted to whatever is asked for in the problem; another column will involve the given information; and the third will involve whatever can be computed from the other two. Thus in the coin problem, I lead up to the chart by asking suggestive questions, as: What does the problem talk about? What does it ask us to find? How do the coins compare in value? Of what importance are their relative values? A cashier puts his nickels, dimes, quarters in separate compartments in his cash register; after counting how many he has of each, how does he find his total receipts?

After a pupil has grasped the rules, variations may be introduced so that x and its functions appear in the second column instead of the first. Frequently a mere rewording of the problem asking for a different unknown will bring this about; thus: A merchant has 200 lbs. of Formosa tea, and 300 lbs. of Ceylon tea which is worth per pound 5c more than twice the other. At what prices shall he sell them to receive $485? And when the pupil is ready to handle fractions, he can solve: A company has a 2 ton truck and a 1½ ton truck. At the end of the month the first truck has handled 100 more tons than 5 times the second. If the number of trips made by both was 335, how many tons were shipped by each truck? The headings of the columns would be: Number of trips, Capacity, Total haul. Also we can use problems dealing with the number of revolutions made by a wheel in going a certain distance. In fact, whenever quantities satisfy a relation $xy = z$, the chart is useful.

The method also has advantages in dealing with problems leading to simultaneous equations; the general procedure is the same, although the rules can not be followed rigidly, for x and y may not appear in the same column, nor can both equations be derived from the last entries. Thus: Find the number of seats and price of admission to a theatre, knowing that if there were 400 fewer seats, the price would have to be 10c more, and if there were 500 more seats, the price could be 10c less to get the same receipts. The three columns would be headed:

[1] Note the similarity between these rules and those stated for distance, rate, and time problems.

[2] Not necessarily the third column.

Digitized by Google

Number of seats, Fee, and Total receipts; and the three horizontal rows would be labeled as "Actual condition" (with x seats and y the price), first and second hypothetical case. Other similar problems are those involving people who share expenses on a trip, trains running under hypothetical conditions, rectangles changed by altering their dimensions, etc.

Problems leading to simultaneous equations also afford an opportunity of showing that the chart is really only a means of tabulating our information. Consider the problem: Eight years ago, A was twice as old as B, nine years hence he will be three halves as old as B, Find their ages. Here the three columns are headed 1912, 1920 and 1929 and the entries made are: Under 1920, x and y for their ages; under 1912, $x-8$ and $y-8$; under 1929, $x+9$ and $y+9$. To the class I explain that since we are dealing with two unknowns we must now have two equations, or two relations between the six entries in the chart. Any two relations will furnish a problem; for example, saying A's age in 1912 is a third of B's in 1929, or B's age now is half the sum of A's age in 1929 and B's in 1912. Such relations relate entries in various columns and rows. If the pupils are invited and encouraged to make and try out a few relations of their own, their conception of an equation and its uses can thus be broadened.

The coin problems mentioned above have variations involving more than a blind use of the chart. Thus: A cashier has \$5.20 in dimes and quarters. After taking out 9 dimes and 1 quarter, he has five times as many quarters as dimes. How many of each did he originally have? Here one equation involves the values of the coins and the second the number of coins. The so-called "work" problems contain an additional variation, for if x and y stand for the number of days required by A and B to do a piece of work, then x and y do not appear in the chart, for it is more advisable to enter $1/x$ and $1/y$ in a column headed "part of work done in 1 day," the other two columns being "days worked" and "total part of work completed."

Problems dealing with mixtures of alloys, or with mixtures of chemical solutions of various strengths are always puzzling to the pupil, chiefly because he can not express the ideas which he knows should enter into the problem. But when he tabulates these items, much of the trouble vanishes even though he does not use in his equation all the data. Thus: A chemist wishes to mix an alloy of 60% copper and 40% nickel with an alloy of 30% copper and 70% nickel to obtain 12 tons of an alloy of

Digitized by Google

42% copper and 58% nickel. How many tons of each shall he use? The chart is:

	Q'n'ty	Copper	Nickel
First alloy	x	$.60x$	$.40x$
Second alloy	y	$.30y$	$.70y$
Final alloy	12	$.42(12)$	$.58(12)$

The reader will notice that the four rules given above have not been followed strictly. The third column is filled from the information in the problem, and the equation is not derived from the last entries alone. (The problem could be solved by following the rules—we have merely tabulated too much information). This does not prove that the charts are useless. They are intended as aids to help backward pupils and to develop orderly methods of procedure. They can be used for still another purpose. Every teacher is confronted with pupils who are not dull but are lazy and plead inability to work a problem when they have not tried it. Before extending too much help to such a pupil, it is useful to insist that he tabulate his information in a chart before he can receive help. The teacher can then see at a glance what the trouble is, and make sure that the pupil has at least made an honest effort.

The best variation to test the pupil's ability to absorb ideas rather than ability to handle a formal method, would be one in which the rules appear to fail so that the pupil must resort to his own ingenuity. Such a problem might be one which does not ask directly for any element specified under the headings of the columns, but which could be determined from them. An illustration of this was given in the paper on time rate and distance problems. Another illustration, which, however, is more of a curiosity and a test of ability to understand the English language, is the classic: Mary is twice as old as Ann was when Mary was as old as Ann is now. The two columns of the chart are headed "is" and "was." The words "Mary is twice as old as Ann was" tell us to enter $2x$ for Mary under "is," and x for Ann under "was." Let us say that d is the difference in years between the two columns. Then we enter $2x-d$ under "was" for Mary, and $x+d$ for Ann in the "is" column. The words "when Mary was as old as Ann is now" tell us that $2x-\mathrm{d} = x+d$. Hence, any numbers that satisfy the relation $x = 2d$ will answer the problem, and their ages might be 4 and 3, 8 and 6, etc.

Digitized by Google

THE TEACHING OF LOGARITHMS AND THE SLIDE RULE IN THE NINTH GRADE.[1]

By C. Eben Stromquist,

University of Wyoming.

The question of introducing logarithms and the slide rule in the mathematics course of the ninth grade is only one of the many problems connected with the reorganization of the high school curriculum in general and of the mathematics course in particular.

Suggestions for teaching logarithms early in the high school have been made before, for instance, by Professor Meyer in School Science and Mathematics for 1905 and by Professor Moritz in the same journal for 1909. According to the report of Professor J. C. Brown, *Curricula in Mathematics*, United States Bureau of Education Bulletin 1914, No. 45, the topic is not taught in the ninth grade in this country, but we find, on the other hand, in his summary of the ninth year work the statement that "the subject of logarithms is introduced in most of the countries, and in some schools in Germany the pupils become familiar with the slide rule." This refers to some sixteen countries studied in his report. We find also that, with practically no exception, the texts on the first year algebra in this country do not contain the topic of logarithms.

It is hardly necessary to urge the importance of logarithms and the slide rule as topics in the high school course of mathematics. Their practical value in all fields that require computations must be admitted by all who are familiar with these powerful and convenient tools. The arguments for introducing the topics as early as in the ninth grade are the following: The student can thereby economize much time in his school work in mathematics and science and he will see a useful application of mathematics. Furthermore, there seems to be a growing tendency, in this country, to reduce the mathematics requirement for graduation from high school to one year and this year would therefore be the only opportunity afforded to teach the topics to many of the high school students.

The real question regarding introducing logarithms and the slide rule in the ninth grade is, therefore: "Can these topics be presented in a manner suited to the age of these students and without sacrificing more important or more suitable material?"

[1]Read before the Rocky Mountain Section of the Mathematical Association of America at Colorado College, April 3, 1920.

Digitized by Google

The purpose of this paper is to outline a method of presenting these topics in the ninth grade.

Topics Needed For Preparation.

The method is based upon a careful choice of examples and problems from the following topics which are needed as a preparation for teaching logarithms or the slide rule.

Tabulation and graphs: This should include tabulating and graphing linear equation and such equations as $y=x^2$, $y=x^3$, $y=x^{\frac{1}{2}}$, $y=x^{\frac{1}{3}}$. Considerable drill should also be given the student in reading from graphs values of y corresponding to given values of x, and vice versa.

Exponents: The student should be taught the meaning, without formal definitions and proofs, of positive and negative, integrals, fractional and zero exponents. He should be given drill in applying, to simple examples only, the four laws of exponents, namely, multiplication, $a^m \times a^n = a^{m+n}$; division, $a^m \div a^n = a^{m-n}$; involution, $(a^m)^n = a^{mn}$; evolution, $(a^m)^{1/n} = a^{m/n}$. The emphasis should be upon simple numerical examples and problems.

Extraction of square root of arithmetic numbers: As special problems under this topic the student should compute, and keep the results for future use: $\sqrt{10}$ (i. e. $10^{\frac{1}{2}}$) to four or six decimal places; then $\sqrt[4]{10}=10^{\frac{1}{4}}$, $\sqrt[8]{10}=10^{\frac{1}{8}}$, and then $10^{y/8}$, for $y=-6, -5 \ldots, -1, 0, +1, +2 \ldots, +8$. If time permits, it is well to compute $10^{y/16}$ to get more accurate results in the work which is to follow.

The preceding preparatory topics are almost invariably included in the first year high school algebra course. The only change suggested is in the nature of the problem material and in selecting for special use certain problems to illustrate square root and the simpler definitions and rules of exponents.

Tabulation and Graph of $x=10^y$.

The student is now ready to tabulate $x=10^y$ for $y = -\frac{6}{8}, -\frac{5}{8}. \ldots 0, +\frac{1}{8} + \ldots +1$. This is simply a matter of collecting and arranging the results already worked out. This will give the following table in which the values of y have been expressed as decimals:

x	0.178	0.237	0.316	0.422	0.562	0.750	1.000	1.334
y $-\frac{6}{8}$	−0.750	−0.625	−0.500	−0.375	−0.250	−0.125	0.	+0.125
x (continued)	1.778	2.371	3.162	4.217	5.623	7.499	10.000	
y (continued)	0.250	0.375	0.500	0.625	0.750	0.875	1.000	

Careful explanations and directions regarding the units to

Digitized by Google

be selected on the coördinate axes should be worked out with the student before he attempts to construct the graph. The selection of cross-section paper will be determined largely by that which is most readily obtained on the market. For this reason, a millimeter paper has been used. The scale on the x-axis is taken 1 unit = 2cm. and on the y-axis, 1 unit = 1cm. The graph can now be constructed from the preceding table for points corresponding to values of y from $y = -0.75$ to $y = +1$. The teacher should insist upon accuracy in locating the points and upon a fine smooth curve, even if this requires repeated attempts in drawing the graph.

Computations From the Graph.

After the student has constructed a satisfactory graph, some drill should be given in reading from it values of x corresponding to given values of y and, conversely, in finding values of y corresponding to assigned values of x. For example, if $y = 0.26$, find the corresponding point on the graph and the required value of x is 1.8, approximately. If $x = 5.2$, it is found that $y = 0.72$. Exercises of the following types should also be given. Find from the graph the number that should replace the question mark in each of the following: $2 = 10^{?}$, $? = 10^{.48}$.

The purpose of these problems is to familiarize the student with the units on the two axes, to enable him to select readily the axis that corresponds to the "number" (x) and to the "exponent" (y), respectively, and chiefly to give him an understanding of the functional relation between the variables x and y. It might be remarked incidentally that the use that can be made of the graph to find values of a given function and to emphasize and clarify the notion of functionality is a feature of graphing that is usually neglected in our mathematics textbooks and consequently in most of the teaching of the subject.

Multiplication of two or more numbers may now be performed by finding from the graph the exponents corresponding to the numbers, adding these exponents, and then finding the number corresponding to this last exponent. Thus, in the problem to find $x = 2.4 \times 3.8$, the computation would be as follows: $x = 2.4 \times 3.8 = 10^{.38} \times 10^{.58} = 10^{.96} = 9.12$. To find $x = 35 \times 1.2$. The exponent of 35 cannot be found directly on the graph, but $35 = 10 \times 3.5$ and so the computation becomes $x = 35 \times 1.2 = 10 \times 3.5 \times 1.2 = 10 \times 10^{.51} \times 10^{.08} = 10 \times 10^{.62} = 10 \times 4.2 = 42$. In general, $x_1 \times x_2 = 10^{y_1} \times 10^{y_2} = 10^{y_1 + y_2} = x$, where y_1 and y_2 are the exponents corresponding to x_1

Digitized by Google

and x_2 and x is the number corresponding to the exponent y_1+y_2.

The operation of dividing x_1 by x_2 is performed in a similar manner with the exception, of course, that we find the difference in place of the sum of y_1 and y_2.

Involution and evolution are readily performed by use of the graph as is illustrated in the following example:

Find $x = (1.8)^3$.

$$x = (1.8)^3 = (10^{.255})^3 = 10^{.765} = 5.8 \quad \text{(approximately)}.$$

Find $x = \sqrt{6.75}$.

$$x = (6.75)^{\frac{1}{2}} = (10^{.83})^{\frac{1}{2}} = 10^{.415} = 2.6 \quad \text{(approximately)}.$$

The rules for the preceding four operations should be stated by the student. Thus, to multiply two numbers, first, express the numbers as exponents of 10 by finding the values of y corresponding to the given numbers, next, add the exponents thus found, and, finally, find the number corresponding to this new exponent. This number is the required product.

Logarithms.

So far, no mention has been made of logarithms, but the foundation has been laid for its definition, for the rules of multiplication, division, involution and evolution by the use of logarithms, and, in the second illustrative example under multiplication, for the meaning of characteristic and mantissa of a logarithm. The student may now be taught the definition and use of logarithms, or simple problems of computation by use of the slide rules may first be taken up.

If the first plan is followed, it is well to introduce the subject of logarithms by first showing the need of a new definition for the relation $x = 10^y$. The student is already familiar with the fact that in order to be able to solve for y such an equation as $x = 8^y$, the inverse operation of multiplication, namely, division, must be introduced and the solution for y gives the inverse function $y = x/8$. Similarly, to solve $x = y^2$ for y we must introduce the new operation of and symbol for extracting square root. The resulting equation, $y = \pm\sqrt{x}$, gives the inverse function of $x = y^2$.

This suggests the need of introducing a new symbol for expressing y as a function of x in the equation

$$x = 10^y. \tag{1}$$

To do this we define y to be the logarithm of x to the base 10 and write this symbolically, $y = \log_{10} x$. (2)

It should be made clear that equations (1) and (2) give the

Digitized by Google

same functional relation between the variables x and y, the only difference being the difference in form and that equation (1) expresses x as a function of y while (2) gives y as a function of x. Stated geometrically, the graphs of equations (1) and (2) are identical. The graph that has already been constructed for $x = 10^y$ can therefore be used for $y = \log_{10} x$ and the student is now ready to multiply, divide, raise to a power, or extract a root by logarithms. It soon becomes clear to him that in the rules of these operations that have already been stated it is only necessary to substitute the word logarithm for the word exponent.

The student will have felt that the table of values for x and y that he has constructed and that he obtains from his graph is not sufficiently accurate for most computations. This affords the opportunity for introducing logarithm tables.

As has already been stated, the slide rule can be introduced either before or after he is familiar with logarithms.

Résumé.

The method of presenting logarithms and the slide rule as outlined in the preceding requires for preparation no material, such as arithmetic and geometric progressions, which is not already in the ninth grade course. The preparation for logarithms depends upon a careful selection of examples and problems under such topics as graphs, square root of arithmetic numbers, and exponents. The problems so selected give more concrete and practical applications than do the artificial problems so often found in our text books.

Constant use has been made of the notion of functional relation in problems involving tabulation, graph, equation, inverse operations and functions, and computing and reading values of the variables from the graph.

The meaning and use of logarithms are introduced in a natural manner that the ninth grade student is able to comprehend, and not in an artificial way by starting with formal definitions and rules.

The method has been tried with several ninth grade classes in first year algebra in the University High School of the University of Wyoming. The pupils are taught the use of the slide rule and by the end of the year have learned how to compute by logarithms the value of any one quantity when the others are given in such formulas as $A = \frac{1}{2}bh$, $C = 2\pi r$, $A = \pi r^2$, $i = ptr$, $A = P(1+r)^n$. This has been accomplished without sacrificing any of the topics that are now generally contained in the first year algebra texts.

Digitized by Google

A STUDY OF EXAMINATIONS AND TESTS.

By Mabel W. Arleigh,
South Pasadena, Calif.

It is customary in most schools to give tests or examinations at intervals. The marks received in such tests are given considerable weight. I think most teachers who watch the daily work closely find considerable difference between the daily marks and the examination marks; sometimes one is higher and sometimes the other.

I have tried out many of the standard tests in several subjects, and always obtained some puzzling results. So I began to question the efficiency of tests, and to wonder how I could test the tests. I determined to try out this question with a beginning algebra class. The results may be interesting to other teachers.

For my point of departure let me refer to Thorndyke, and the theory of identical elements. Identical elements may be either "elements of procedure," or "elements of substance." Now, in an examination we use identical elements of substance, that is, we test on the same subject matter as in daily lessons. But what of elements of procedure? In an examination the procedure is always radically changed, is it not? The daily lesson may be oral, or written, or blackboard work, or a combination, but in the test, the pupil has the "idea of the test" to contend with, and that "idea" seems to be a serious hindrance in many cases, according to the personal reaction of each individual pupil. I append the record of the algebra class which I selected for this test, for the year 1918-1919, in the high school at Corning, Calif.

There were twenty-two pupils in the class at different times during the year, but only fifteen were in all the year, so I give their marks only. At the end of eight weeks I gave a written examination, ten questions, marked on the scale of ten, each question marked right or wrong. It was an easy examination but only two pupils passed. I did not return these papers, nor tell them of their poor rating, but I gave them examinations four days in succession gradually increasing their difficulty. The results possessed the usual puzzling features. The class work and home work of all pupils was above passing, but the class average in every examination was below passing. However, all but two pupils passed in at least one of these tests. The object in repeating the tests was to accustom the pupils to the "procedure."

Digitized by Google

I gave no more examinations till January. Then I repeated the very examination that I had given last in November. Some stood higher, and some lower than two months before. The errors were quite absurd, nervous errors, I should call them. It was the novelty of the test, the difference of procedure, which interfered with their work. I continued daily tests for four days, increasing their difficulty, and the marks now rose to the level of the daily normal. There were some surprising rises.

Two months later I gave four more examinations in succession. The results were similar to the preceding, but the marks were better. Early in May we completed the required work for the year, and I gave a series of final examinations. I offered this inducement. As soon as any pupil passed seven perfect examination papers, he was excused from further examinations, and from home study, and could devote his class time to advanced work. This was advanced algebra, or geometrical construction, or project problems, or logarithms, or mathematical games. In a very short time all the pupils I had had all the year had met this requirement of seven perfect papers. Even the other pupils met it in time.

12 examination marks of 15 algebra pupils on successive days in:

	November				January				March			
M	3	3	4	7	1	5	8	9	8	10	10	10
G	8	9	10		8	9	10	10	10	8	10	10
Z					2	6	3	8				
N	4	8	8	7	4	6	9	8	9	9	8	10
H	7	10	8	7	8	10		10	9	8	9	10
F	8	10	9	5	8	9	7	9	8	9	10	10
O	7	8	7	7	5	9	9	10	7	9	9	10
D	5	6	7	8	4	5	4	8	9	10	10	10
J	6	7	8	6	9	8	9	9	9	7	9	10
C	4	7	9	7	9	8	9	10	10	9	8	10
L	7	8	9	7	9	9	8	10	10	10	10	10
S	4	4	5	8	1	2	4	10	6	5	9	10
B	2	3	5	6	1	5	4	9	3	9	10	9
W	3	5	7	8	3	6	4	10	8	10	9	10
R	3	8	6	5	7	7	9	9	4	8	10	10

Now I think a study of this experiment shows that if an examination is given in a way that differs ever so slightly from the procedure in the daily lesson it is not a fair test. On the other hand if the test is repeated until that method of procedure becomes habitual, then and then only is it a test.

During twenty years of teaching I have again and again seen my best pupils fail on tests purely on account of nerves. Then

Digitized by Google

some pupil, who in daily work appears weak, stolid, slow, inattentive, will excel in a test, perhaps because the silence helps him concentrate. The examination at infrequent intervals seems to be more a test of nerve than a test of subject matter. If this be true then the mystery of the examination clears. In teachers' examinations we often find the very bright, capable girl who fails, and the dull one who passes. One of the best teachers I have ever known never passes an examination, while some of the poorest I know always pass.

The idea of the standard test is sweeping the country. Pupils and teachers are ruthlessly judged by these. A psychologist from some University was giving tests at a normal school where I was teaching. He took each child alone, and gave him tests to determine his mental age. I observed for a time. Some of his results tallied with my own grading of the pupils, and some differed widely. One boy, aged seven, was brought in. He graded him age 5½, mentally deficient. As a matter of fact the boy was in the fourth grade and exceptionally bright. Later in the day I met the boy, and he volunteered this information, "Say what was that fool test this morning? I sure fooled the old geeser, didn't I? I wanted to hurry back to the library." Yet the boy acted serious and stupid during the test. Quite a number of our bright children were graded low by this doctor, possibly because they did not take him seriously, though he certainly took himself seriously. Some of our dull pupils he graded high.

If the infrequent test is not a true test, what is, and how should the present procedure be modified? Should we give four or five tests in succession each time? If so, should we average the results, or take the last, or take the highest, or take the average of those above passing? For myself, I discarded the failure papers, and repeated the test till I obtained satisfactory results. It was my procedure to drill on daily work till I had satisfactory results, so I did the same with tests. Is that fair? Is any other way fair? If "passing an examination" is a desired result, should we not drill on examinations till the passing of them is accomplished successfully? To teach algebra is not enough. We must also teach the pupil to pass an algebra examination, and to know that he can do it, which is quite a different thing.

I should like to know what experiments other teachers may have made in this direction, or what deductions they may make from mine.

Digitized by Google

SOME TANGIBLE RESULTS FROM A COURSE IN GENERAL SCIENCE.[1]

By George Mounce,

LaSalle-Peru Twp. High School, LaSalle, Ill.

The motive that gave rise to the course in General Science in the high school had its inception in the desirability of giving the boys and girls, on entering, an appreciation of their industrial, technical, economic and hygienic environment, and the content of the course at any period of its development has been determined by the attitudes of social opinion regarding the prominent sciences of that period.

In tracing the history of General Science we note that it really began with the popular lectures of Faraday, Tyndall and Huxley. Since the prominent science at that time was geography, we can readily see how physiography grew. At first physiography contained much of physics and chemistry, but later it become too specialized, due to the rapid growth of geology in the colleges and to the influence on physiography content by college trained teachers in the high school. A reaction set in for an inductance into the course of more of the physical and biological sciences. Later the economic, social and hygienic points of view were incorporated, thus rounding out a course embracing the industrial, technical, economic, and hygienic environment of the pupil.

In these days when educational arbiters of fate are abroad in the land preaching the gospel of standard tests and score cards, it behooves the teacher of General Science to stop long enough to take an inventory of tangible results, and it is my purpose to set down a few results which, from seven years' experience and observation in active teaching, I consider tangible.

The first and most important result is the creation of a boundless enthusiasm for the wonders of science. I have watched with much interest the effect on the pupil of the unfolding of the wonderful world of science all around him. Nothing that he has studied in the grades approaches it in intensely fascinating interest. From boyhood he has been living in an environment of automobiles, telephones, flash lamps, push buttons, motors, gas meters, kites, and that inherent something which we call natural curiosity has been seeking more or less blindly for an explanation of the why and the law of these familiar things. The demonstrations open up to him a new world. His enthus-

[1]Read before the General Science Section of the C. A. S. & M. T. at Lake View High School, Chicago, Nov. 28, 1919.

Digitized by Google

iasm sets his face aglow and his appreciation knows no bounds. This enthusiasm and appreciation for the wonders of science is the main spring that impels the boy to carry much useful and helpful information from the class room to the home. In the home he is the center of radiation to all the rest of the family. This new knowledge results in economy of gas in the kitchen range, economy of fire, economy of coal. It results in better ventilation of living rooms, in better lighting as to quality and distribution, in better sanitation about the home. He educates the family until the members are familiar with such terms as calorie, protein, toxin, antitoxin, bacteria, volts, amperes.

For years a large majority of people in our country have been familiar with medical terms. When the physician informs the anxious mother that her husband is suffering cerebro spinal mengitis lethargetic encephyletis she listens with some degree of understanding but when her boy explains to her that the low voltage that dark afternoon was responsible for the poor service that she got out of her electric iron, she looks at him in blank amazement.

I can give you many cases in which students in General Science have carried practical knowledge to their homes and put it into use. A few instances will suffice. One boy was much impressed with the experiment showing the efficiency of tungsten lamps. We had worked out a chart showing the efficiency of different lamps. This boy went home, armed with this table and started an active campaign in favor of the immediate removal of the old carbon lamps that had done duty for years, and a substitution of 40-watt tungstens. His father, a practical business man was soon convinced, and the result was better light for less money.

An electric iron was brought to my lecture room with a request that I tell him why it wouldn't heat like it used to do when his parents lived in a small country town. He had taken the iron to a local electric repair shop, and been told that it was in good working order. The bill was paid but still the iron wouldn't get hot enough for use. We had just developed the idea of electrical pressure, ampere, and watt. I had the boy clean the name plate on the iron with some emery paper and after the rust was removed he found to his surprise that the iron was designed to be used on a 220-volt circuit. He at once reasoned out that the iron was receiving but half the amperage on the

Digitized by Google

110 volt circuit in his home, and consequently but one fourth of the necessary heat required for practical use. It is needless to say that the boy lost some of his respect for the repair man's knowledge of practical electricity and that General Science gained a staunch friend.

The General Science course often gives the initial impulse that starts many pupils reading scientific books and into investigation on their own accord.

Four years ago a Polish boy came into our high school as a freshman. He was assigned to my class in general science. At once he became interested. He would hang around in the lecture room after the class passed the seventh period, to ask questions. I let him have books on scientific subjects. He read a great many stories of useful inventions, Faraday's History of the Candle, Jink's Chemistry for Young People. I sold him apparatus to equip a small laboratory at home where he carried on some interesting experiments. In his junior year he was in my physics class and during that year he built a fine switch board for our physics laboratory, worked out some very difficult wiring circuits on it. In his senior year he took complete charge of the photographic department that takes all the pictures for our high school annual. He read all the books and magazines on photography that were in our library. He would spend his Saturday morning in the dark room, mastering the fine points of a hobby that will be an ever increasing source of pleasure to him as years pass. He knew nothing of science when he started, but General Science opened up a new field to him.

A third tangible result is that the General Science course establishes a bond of helpful friendship between the teacher and pupil. This bond draws the pupil to the teacher after school hours for information and help on questions in which he is most interested. He finds the teacher a walking encyclopedia of scientific facts. To me this is one of the most interesting phases of science teaching. Woe be unto the prestige of the teacher who is not familiar with the various booksups in wireless or the peculiar eccentricities of detectors. The boy who owns and operates a commercial set will be little interested in an antiquated filings coherer type, unless it be from the historical standpoint.

Recently a boy asked me how the temperature of the water in the cooling system of the Hudson car was controlled by a thermostat. I had to acknowledge that I didn't know but I'd find out. I then showed him the principle of the thermostat. Only the

Digitized by Google

other day a boy came to me with a drawing for bell ringing device for country railroad crossings. He wanted to know if it would work. I was surprised at the ingenuity of the scheme. As the train approached the crossing a bell would ring and a warning light come on. The light was designed for protection at night. I gave the boy some help regarding contacts, batteries, etc., and urged him to make a working model of his scheme.

The General Science in our high school has been responsible for the steady improvement in the grade of the students electing physics and chemistry. It is acting as a selecting and weeding out device. Pupils who are interested in General Science elect physics in the junior year and chemistry in the senior year.

I made a point of reminding my pupils at the close of the semesters in General Science that if they enjoyed the course they would find physics interesting and helpful in further explanation of the laws of nature in which they live. During the past seven years the total number electing physics who had previously had General Science has increased from 14 per cent in 1912 to 65 per cent in 1919.

Those students who have had General Science rank best in physics and chemistry. They have acquired a working vocabulary of scientific words. Many of them have acquired that scientific attitude of mind that enables them to attack and solve problems with but little help from the teacher.

In an effort to simplify the apparatus used in General Science demonstrations, I have brought into our lecture room such familiar articles as aluminum pans, teakettles, quart cups and measuring vessels; a gasoline stove; a gas plate with two burners, a small one within a larger one; a fireless cooker made from a candy pail, a pair of steelyards for demonstrating the law of levers, electric hot plate, electric iron, a large electric bell, the parts of which are visible to the entire class from the lecture table.

I have collected a various assortment of lamps from the old grease lamp of our ancestors to a modern street arc, and a thousand-watt nitrogen. Many of these articles have been donated to us. An electric shop gave us an electric percolator made largely of glass, also a set of parts showing every step in the manufacture of a tungsten lamp. The Citizen's Lighting Co. let us have a gas meter with glass sides, through which all movable parts are plainly visible. These large pieces of apparatus have given such satisfactory results that I have adapted many of them

Digitized by Google

to my laboratory work in physics. Toy apparatus command little respect from a real live pupil.

To meet the need of a piece of apparatus to show the relation of temperature to pressure I constructed one from a quart mercury distilling retort and a pressure gauge that read both pressure and vacuum. With this apparatus it is an easy matter to secure a temperature of 150°C. In this retort, beans will cook in a few minutes. This apparatus has replaced the old hypsonometer and mercury monometer which I used to use in my physics classes. To be sure there are fewer thrills occasioned by impacts of thermometers against the ceiling. Such upheavals always result in the discomfiture of the teacher to the huge delight of the pupils.

PEAT AS A GAS PRODUCER.

Peat consumed in a properly designed gas producer yields gas of good quality and in abundant quantity in comparison with the yield from coal and also many valuable by-products. This is perhaps the most effective utilization of peat fuel for generating heat and power, because peat that is to be used in this way does not need to be so carefully prepared nor so thoroughly dried as peat that is to be consumed for domestic purposes or under steam boilers. Gas-producing plants using peat fuel are operated in England, Ireland, Germany, Sweden, Italy, and Russia, but in the United States, although experiments have been made, no gas-producing plants are operated with peat.

SLATE.

The use of slate for roofing is apparently on the decline, although a part of the falling off in production in recent years is due to war-time curtailment of building, according to a report recently issued by the United States Geological Survey, Department of the Interior. The major part of the slate produced in this country is, contrary to the general impression, used on the inside rather than the outside of buildings, for such purposes as making stationary washtubs, electrical switch-boards, and blackboards, and the output for these purposes has been fairly constant for the last ten years. The report may be obtained on application to the Director of the United States Geological Survey, Washington, D. C.

QUICKSILVER PRODUCED IN THE UNITED STATES.

Between January 1 and March 31, 1920, inclusive, 4,899 flasks of quicksilver, each of 75 pounds net, were produced in the United States, according to F. L. Ransome, of the United States Geological Survey, Department of the Interior, who obtained the figures from the producers. This is 852 flasks less than the output in the fourth quarter of 1919 and 1,226 flasks less than that in the first quarter of 1919.

California produced 3,994 flasks, and Texas, Oregon, and Nevada together produced 995 flasks. There were 10 productive mines in California and 1 in each of the three other producing States. Less than 100 flasks were produced by mines outside of California and Texas.

The quicksilver on hand at the mines or in transit to market at the end of the quarter amounted to 4,160 flasks.

The average monthly prices of quicksilver per flask in San Francisco in the first three months of 1920, as quoted in the Mining and Scientific Press, were $89 in January, $81 in February, and $87 in March.— *U. S. Geol. Survey Bul.*

Digitized by Google

PROBLEM DEPARTMENT.

Conducted by J. A. Nyberg.
Hyde Park High School, Chicago.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. If you have any suggestion to make, mail it to him. Address all communications to J. A Nyberg, 1044 E. Marquette Road, Chicago.

SOLUTION OF PROBLEMS.

636. *Proposed by Walter Warne, State College, Pa.*

Obtain all the values of x and y in the equations

$$x+y = 14-y^2,$$
$$x^2y^2+xy^3+xy = 600-x^2y^4-2x^3y^3.$$

Solution by M. G. Schucker, Pittsburgh, Pa.

Transposing in the second, equation

$$(x^2y^4+2x^3y^3+x^4y^2)+(xy^3+xy)-600 = 0$$

or

$$y^3+y = 24/x \text{ or } -25/x$$

From the first equation, $y^3+y = 14-x$.

Hence, $14-x = 24/x$ or $-25/x$.

The solutions are: (2, 3), (2, −4), (12, 1), (12, −2), and

$$x = 7\pm\sqrt{74},\ y = [-1\pm(29\mp4\sqrt{74})^{\frac{1}{2}}]/2.$$

Also solved by C. E. Githens, Wheeling, W. Va.; A. Pelletier, and the Proposer. The irrational solutions were omitted in the solution by Elizabeth Weaver, Sunbury, Pa. Nelson L. Roray, Metuchen, N. J., entered each solution twice but the editor can see no reason for considering them double solutions as that would mean that the curves represented by the given equations pass through the points (2, 3), . . . *twice.*

637. *Proposed by A. Pelletier, Ecole Polytechnique, Montreal, Can.*

A, B, C are three numbers having, respectively, α, β, γ digits. Find the number of digits in the expression $(AB/C)^n$.

Solution by the Editor.

The logarithms of A, B, C will have $\alpha-1$, $\beta-1$, $\gamma-1$ for characteristics, and the log $(AB/C)^n$ will have a characteristic equal to $n(\alpha+\beta-\gamma-1)$. Supposing that the mautissa for A and B were .9999 and for C was .0001, the greatest possible error is an increase of $n(1.9997)$. From the characteristic of the logarithm, the number of digits in the expression itself is determined.

Also solved by the Proposer.

651. *Proposed by Walter R. Warne, State College, Pa.*

If x, y, z, be in harmonic progression, a, x, b in arithmetic progression, and a, z, b in geometric progression, show that

$$y = 2(a+b)[(a/b)^{\frac{1}{2}}+(b/a)^{\frac{1}{2}}]^{-2}.$$

Solution by Homer A. Obenauf, Culver Military Academy, Culver, Ind.

From the given facts about the progressions,

$$y = 2xz/(x+z),\ x = (a+b)/2,\ z = \sqrt{ab}.$$

Then, by substituting x and z in the expression for y, we have

$$y = 2(a+b)\sqrt{ab}/(a+2\sqrt{ab}+b) = 2(a+b)/[(a^{\frac{1}{2}}+b^{\frac{1}{2}})/a^{\frac{1}{2}}b^{\frac{1}{2}}]^2$$
$$= 2(a+b)[(a/b)^{\frac{1}{2}}+(b/a)^{\frac{1}{2}}]^{-2}.$$

Also solved by N. Barotz, New York City; H. G. Donovan, Senior at Concord High School, N. H.; T. E. N. Eaton, Redlands, Cal.; Irvin E. Kline, Atlantic City, N. J.; R. T. McGregor, Elk Grove, Cal.; J. S. Morris, Central Square, N. Y.; J. H. Packham, Collegiate Institute, Owen Sound, Ont.; A. Pelletier; J. L. Riley, Stephenville, Tex.; N. L. Roray; M. G. Schucker, and the Proposer.

Digitized by Google

652. *Proposed by Walter R. Warne.*

A V-shaped trough has an angle of 60°, and is six feet long. A sphere 12 inches in diameter is placed in it and rolls throughout its length. How many revolutions does it make?

Solution by Wm. A. Pagelow, Student in the Industrial Department of The W. L. Dickinson High School, Jersey City, N. J.

The angle of the trough, ADC, is 60°. The ∠AOB, formed by the radius of the ball from the point of contact and the horizontal OB, is 30°. Draw AB from the point of contact, A, ⊥ to OB. Then in the 30° rt. △OBA, AB = AO/2. Hence the circumference of the circle formed by the point of contact equals 1/2 the circumference of the ball.

The number of revolutions the ball will make will be twice the number made by a ball 1 ft. in diameter rolling 6 ft. on a plane, or $2 \cdot 6/\pi = 12/\pi$.

The above solution and two others by Edward Kunath and Madison R. Hunt, also students in the same school, were sent in by N. L. Roray. Also solved by Wm. H. Brown, Amherst (Mass.) High School; H. G. Donovan; Irvin E. Kline; J. H. Packham; A. Pelletier; J. L. Riley; Wm. R. Silveys, John Marshall High School, Richmond, Va.; T. F. Tyler, Fremont, Nebr.; and the Proposer. Also two incorrect solutions received. M. G. Schucker was the only one to call attention to the fact that if the trough is closed at both ends, the sphere can roll only 66 in. making $11/\pi$ revolutions.

653. *Proposed by J. Carl Kamplain, Student, University of Chicago.*

Given a triangle ABC with $a = 6$, $b = 5$, $c = r$. Find a point P such that PA : PB : PC = $c : b : a$.

Solution by J. H. Packham.

Since PA : PB = $c : b$ the locus of P will be the circle described on XY as diameter, X and Y being the points of internal and external division of AB in the ratio $c : b$. Similarly, a second locus of P will be a circle that divides BC in the ratio $b : a$. The intersections of the two circles answer the question, and there may be two, one, or no solutions.

Also solved by A. Pelletier. Two incorrect solutions received, one of which assumed that r was the radius of the inscribed circle, in which respect the statement of the problem is misleading.

654. *Proposed by C. N. Mills, Heidelberg University, Tiffin, Ohio.*

Three circles, whose radii are r_1, r_2, r_3, touch one another externally. Show that one of the sides of the triangle made by joining the points of contact, is

(1) $$2r_1\left[\frac{r_2r_3}{(r_1+r_2)(r_1+r_3)}\right]^{\frac{1}{2}};$$

(2) The area of the triangle formed by the points of contact is to the triangle formed by the centers of the circles as

$$2(r_1r_2r_3) : (r_1+r_2)(r_1+r_3)(r_2+r_3).$$

Solution of part (1) by Harold G. Donovan.

Let A,B,C be the centers of the circles whose radii are r_1, r_2, r_3; and M be the point of tangency of circles A and B, N the point for A and C, R the point for B and C. Then

$$MN = 2r_1 \sin(A/2) = \sqrt{(s-b)(s-c)/bc} = 2r_1\left[\frac{r_2r_3}{(r_1+r_2)(r_1+r_3)}\right]^{\frac{1}{2}}$$

Solution of part (2) by Nelson L. Roray.

$$\angle MNR = \angle(A+C)/2. \qquad NR = 2r_2\left[\frac{r_1r_3}{(r_2+r_3)(r_2+r_1)}\right]^{\frac{1}{2}}$$

$$\frac{\triangle MNR}{\triangle ABC} = \frac{MN \cdot NR \cdot \sin(A+C)/2}{AB \cdot AC \cdot \sin A}$$

Writing $\sin A = 2\sin(A/2)\cos(A/2)$, and making the proper substitutions, we get the desired result.

Both contributors solved both parts, but the editor selected what was easiest to print. Some solutions which made no use of trigonometry but only the area of a triangle in terms of its sides are long and complicated with fractions and radicals. Also solved by Irvin E. Kline, Homer A. Obenauf, J. H. Packham, A. Pelletier, J. L. Riley, W. R. Warne.

Digitized by Google

655. *Proposed by C. N. Mills.*

If a, b, c, the sides of a plane triangle, be in harmonic progression, show that

$$\left[\frac{\sin(A/2)}{\sin(C/2)}\right]^2 = \frac{\cos B-\cos A}{\cos C-\cos B}.$$

I. *Solution by Norman Anning, Ann Arbor, Mich.*

Lemma: When $L+M+N = 180°$, $\sin L\sin M = \cos L\cdot\cos M+\cos N$.

Since $a/c = (a-b)/(b-c)$, $ab-ac = ac-bc$,

$\sin A\sin B-\sin A\sin C = \sin A\sin C-\sin B\sin C$,

$\cos A\cos B+\cos C-\cos A\cos C-\cos B = \cos A\cos C+\cos B-\cos B\cos C-\cos A$.

$(1-\cos A)(\cos C-\cos B) = (1-\cos C)(\cos B-\cos A)$,

$$\frac{\cos B-\cos A}{\cos C-\cos B} = \frac{1-\cos A}{1-\cos C} = \left[\frac{\sin(A/2)}{\sin(C/2)}\right]^2.$$

The first equation of the last line shows that if a, b, c, the sides of a triangle, are in harmonic progression then $1-\cos A$, $1-\cos B$, $1-\cos C$ are also in H. P.; and this, in turn, shows that $\sin^2(A/2)$, $\sin^2(B/2)$, $\sin^2(C/2)$ are in H. P.

II. *Solution by A. Pelletier.*

We have
$$a = b\cos C+c\cos B. \quad (1)$$
$$b = a\cos C+c\cos A. \quad (2)$$
$$c = a\cos B+b\cos A. \quad (3)$$

Subtracting (2) from (1), and (3) from (2), give

$$(a-b)(1+\cos C) = c(\cos B-\cos A)$$
$$(b-c)(1+\cos A) = a(\cos C-\cos B)$$

Dividing, and using the relation $a/c = (a-b)/(b-c)$,

$$\frac{a^2}{c^2}\cdot\frac{1+\cos C}{1+\cos A} = \frac{\cos B-\cos A}{\cos C-\cos B}.$$

$$\frac{\sin^2 A}{\sin^2 C}\cdot\frac{\cos^2(C/2)}{\cos^2(A/2)} = \left[\frac{\sin(A/2)}{\sin(C/2)}\right]^2 = \frac{\cos B-\cos A}{\cos C-\cos B}$$

Also solved by H. G. Donovan, Homer A. Obenauf, J. H. Parkham, A. Pelletier (two), J. L. Riley, N. L. Roray, W. R. Warne (three).

LATE SOLUTIONS.

646. C. M. Cramlet, College Place, West Va.
647. C. M. Cramlet; M. G. Schucker.
648. C. M. Cramlet; N. Anning; Wm. R. Silvey; M. G. Schucker.
649. N. Anning; M. G. Schucker.
650. N. Anning; M. G. Schucker.

Later: from A. Sapthrishi Aiyar, Gen. Sec. of the High School Association, Mayavaram, India, solutions, by K. Gopalau, a student in form VI in the Municipal High School, of problems 636, 647, 650, 651, 654, 655 have been received. It would be a matter of great interest to the readers of SCHOOL SCIENCE AND MATHEMATICS to hear from our friends how mathematics is taught in India, what texts are used, the size and organization of the classes, etc.

PROBLEMS FOR SOLUTION.

666. *Proposed by Daniel Kreth, Wellman, Ia.*

Show that when n is any prime number, $(x-1)^n$ and x_n-1 will have the same remainder when divided by n.

667. *Proposed by Abigail Glenn, Student, Chicago Normal College.*

Through three given points in the same straight line, construct three lines which shall form a triangle inscribed in a given circle.

668. *Proposed by A. Pelletier, Ecole Polytechnique, Montreal, Can.*

Prove that the diameter AD of the circle circumscribing the triangle ABC is divided by BC in the ratio $\tan B\cdot\tan C : 1$.

669. *Proposed by Herbert C. Whitaker, Philadelphia.*

At a certain time, a train overtakes a man, A, and 10 seconds thereafter passes him. The train overtakes another man, B, 20 minutes after

Digitized by Google

passing A, and 9 seconds thereafter passes B. Counting from the time the train passed B, how soon will the two men meet?

670. *Proposed by Herbert C. Whitaker, Philadelphia.*

What will be the radii of five equal circles which will be tangent to a circle whose radius is 12 inches and also tangent to one another?

AN INVITATION TO THE STUDENTS.

The reader may have noticed that several high school students are sending in solutions to the problems. The editor believes that they ought to be encouraged. After talking over the matter with some of the contributors, it was decided that each month one of the problems should be devoted especially to these future mathematicians. In the present number it is No. 670, and hereafter it will be the last of the five proposed. Teachers are asked to call the attention of the students to this problem, and to encourage its solution. Many high schools have organized clubs in mathematics and their attention should be called to the plan. If the solutions are radically different more than one will be published; the others will be ranked according to judgment shown in omitting or inserting details, and clearness and logic of presentation. Thus, in the solution of No. 652 in this copy, the writer should not talk of $\angle AOB$ before telling how the line AB is drawn. Solutions should give the name of the high school as well as the town.

The success of this plan depends naturally on the teachers. Suggestions are invited as to the nature of the problems, and on such questions as whether trigonometry or advanced algebra should predominate during the first half of the year, the geometry being reserved until the second half.

A NOTE ON NEGATIVES.

By Frank H. McMackin, Ph.D.,

Wm. L. Dickinson High School, Jersey City, N. J.

A suggestion of one method for teaching little folks the *raison d' être* of negative numbers.

Can you recall how you learned to subtract numbers in the primary school? To subtract 5 from 7, i. e., 7—5, you counted out 7 splints | | | | | | | thus, then picked up 1, 2, 3, 4, 5 and those remaining, when counted, gave the answer. There is another way you might have been taught to subtract and probably you would not have found it any more difficult.

Suppose that we have a person who can count but who cannot subtract. We might proceed to teach him subtraction as follows. We would say to him, if you want to subtract 5 from 8, that is to do the problem 8—5, find the number 8 on this chart and starting from there count 5, the other number, spaces to the left — the number you see there will be the answer.

(Do several such problems getting the pupils used to the method and emphasizing the fact one must always begin counting at the minuend.)

Suppose now we tell our pupil to subtract 4 from 3, that is to do the problem 3—4. Not being versed in the niceties of arithmetic, he would not say that it cannot be done but he would immediately find 3 on the chart and count to the left 1, 2, 3, then he would hesitate a moment, count one more space beyond 0 and say, "Well there is the answer but what do you call it?"

That is exactly the point, what name do we give to that answer? The only reason you could not do the problem 3—4 in arithmetic was because arithmetic furnished no way to represent its answer. Algebra furnishes a name for that answer, consequently such a problem can be and is done in algebra.

How can we arrive at a proper name for this answer? Let us go back again to the splint method of substraction and do first the problem

Digitized by Google

4—3. We have 4 splints and are to subtract 3. If we take one
4—3 splint away we would have left 3 splints but 2 still to be
3—2 subtracted, 3—2. If we take another away we have left 2
2—1 splints and 1 to be subtracted, 2—1. And if we take a third
1—0 one away we have left 1 splint and none to be subtracted.
1 We call 1 the answer and notice that we say nothing in the answer about the fact that we have none left to be subtracted.

In a similar way let us subtract 4 from 3, that is do the problem 3—4. Put down 3 splints. If we subtract 1 we have left two splints,
3—4 and three to be subtracted, 2—3. Take away another one,
2—3 we have left 1 splint and 2 still to be subtracted, 1—2. Tak-
1—2 ing away another we have left no splints and one still to be
0—1 subtracted, 0—1. Here as in the problem 4—3, in writing the
—1 result we do not mention the fact that we have no splints left, we never mention the things we do not have, we simply write

l, read minus one or negative one, which we call the answer to the oblem. If we subtract 4 from 3 we have left one to be subtracted, aus one, negative one, —1.

Similarly for all other negative numbers.)

THE POTASH DEPOSITS OF ALSACE.

)ne of the outstanding questions of the great war was "Will Alsace be :ored to France?" This question, full of national interest and appeal t was to France and Germany, was of still wider commercial interest, the only known deposits of potash of proved commercial value in the ld except the deposits near Strassfurt, Germany, are in Alsace. The ·ch for deposits in the United States, however, is being continued, and hat search a study of the origin, extent, and value of the deposits in ace is likely to be very useful. For this reason Hoyt S. Gale, of the ted States Geological Survey, and Frank K. Cameron, of the Bureau ines, were sent to Alsace early in 1919, soon after the armistice had n signed, to examine and report upon the deposits there.

Location, Depth, and Character of the Deposits.

The potash deposits of Alsace lie beneath an open stretch of the valley he Rhine in southern Upper Alsace, about 25 miles north of the Swiss ler. No evidence of either the potash or of the large masses of com- n salt that are associated with it is found at the surface; the potash discovered only by borings put down in search of coal. Under the nan rule a large part of the potash field was owned and operated he great potash monopoly, the German Kali Syndikat. All the potash erties in this region are now in the hands of representatives of the ich Government.

he potash deposits lie at depths ranging from 1,200 to 2,200 feet be- the surface, in two beds, one about 60 feet below the other, which are d through concrete lined shafts, somewhat as coal is mined. The arance of the deposits in place is striking. They present high walls of kling crystalline salts, banded in nearly horizontal more or less wavy es of red and white, resembling a part of an immense flag. Much e crude material is used for fertilizer after crushing only. In the re- g processes the mother liquors are used repeatedly, as the accumula- of impurities in them is slow, this being considered one of the ad- ages which the French field has over the German. The resultant uct from the refining of the Alsatian potash is a high-grade chloride.

S. Geol. Survey Bul.

Digitized by Google

REPORT OF BIOLOGY TEACHERS ON RECOMMENDATIONS FOR A NEW COURSE OF STUDY FOR THE HIGH SCHOOLS OF CHICAGO.[1]

Recognizing the sound pedagogical principles set forth in the pamphlet, Cardinal Principles of Education, by the National Committee on Reorganization, we desire to base our recommendations upon the definition of education which is stated therein as follows:

"Education in a democracy, both within and without the school, should develop within each individual the knowledge, interests, ideals, habits and powers whereby he will find his place and use that place to shape both himself and society toward ever nobler ends."

We hold that biology is unique among secondary school subjects, when properly taught, in serving a greater number of the ends of education than any other single subject and that it should furnish a part of the training of every boy and every girl who is to contribute to the depth and breadth of the democracy in which each is later to take an active part. In support of the contention just stated, we desire to show in concrete form the extent to which biological training contributes to the seven main objectives of education.

I. Health.
   1. Relations of other organisms to man a basis for successful preventive medicine.
      a. Bacteria, beneficial and injurious.
      b. Insects and disease.
      c. Animal parasites.
      d. Rats and bubonic plague.
   2. Knowledge of plant and animal requirements leads to a better understanding of human requirements.
      a. Food.
      b. Air.
      c. Water.
      d. Elimination of wastes.
   3. Knowledge of conditions for proper metabolism in plants and animals makes clear the importance of
      a. Physical exercise.
      b. Bodily cleanliness.
      c. Civic hygiene.

II. Command of fundamental processes.
   1. Closer coordination of English and natural science studies would secure
      a. Definite expression of original thought.
      b. Language as an art.
      c. A saving of needless duplication of effort.
   2. Enthusiasm resulting from a stimulation of a natural interest in living things results in a spontaneity of expression —an end of effective English teaching.

III. Worthy home membership.
   1. The biological sciences teach as no other subject can, fundamental knowledge and relationships of sex.
      a. Home and family the ideal fundamental unit.
      b. Educate for fatherhood and motherhood.

[1]EDITORIAL NOTE: This paper is the report of a committee of Chicago biology teachers of which Mr. Jerome Isenbarger was chairman. It is printed with the desire that it may assist teachers of biology at large in formulating their own ideas and ideals, and thus enable them to approach their administrative officers with a legitimate demand for the required biological course.

Digitized by Google

c. The approach being natural and biological, a wholesome attitude toward sex and reproduction is secured in mixed classes without offense.

d. Facts of sex and reproduction considered a normal part of knowledge.

e. Biology teachers have gone beyond the experimental stage in teaching sex and reproduction. It is being done, but all pupils in the high school should receive this instruction.

2. Food values and clothing values should be studied by boys as well as by girls.

a. Plant and animal foods.

(1) Luxuries.

(2) Economical selection.

(3) Vitamins.

b. Wool and other animal materials.

c. Cotton and other plant materials.

IV. Vocation.

1. Biological sciences prevocational.

a. Agriculture.

b. Dentistry.

c. Medicine.

d. Nursing.

e. Housekeeping.

f. Horticulture.

g. Forestry.

h. Art.

i. Pharmacy.

2. Biology will help a pupil to select a vocation. A year of a biological science will furnish a strong indication as to whether one of the vocations of the list should be selected or avoided.

V. Citizenship.

1. "Civic biology consists in that group of problems in the control of living nature to solve which requires that a community unite in working together intelligently. Such problems must be made the vital part of the education of every citizen for in no other way can they ever be solved."[2]

a. Flies and mosquitoes, allowed to breed on one's premises, may prove a menace to neighbors.

b. Scale insects and weeds are no respectors of fences.

c. Each individual's carelessness or ignorance affects others. The fact that some people allow the brown rat to breed costs the country $500,000,000 each year.

d. Protection of birds, a civic duty.

e. Biological information presses duties of citizen as neighbor, voter, taxpayer.

f. Cooperation necessary to help control balance of life.

2. "The problem of civic biology is to make it possible for everyone to know what these forces are, for good or for ill, and to understand how to do his part for his own good and for the good of the community."[3]

[2]Hodge & Dawson, Civic Biology.

[3]Hodge & Dawson, Civic Biology.

Digitized by Google

VI. Worthy use of leisure.

1. Forms or helps to form lifelong interests leading to active outdoor diversions.
   a. Bird study.
   b. Flower culture and flower and other plant study.
   c. Insect collecting and insect study.
   d. Fishing and hunting.
   e. Excursions at home and abroad.
   f. Poultry keeping.
   g. Bee keeping.
   h. Gardening.
2. Cultivates a love for beauty, a basis of art.

VII. Ethical character.

1. Tends to secure cooperative good will.
   a. Cultivates intellectual honesty,—"an outgrowth of experience with facts which begets faith in the order of nature and in the workings of its laws and the will to order one's life in accordance with them."[4]
   b. Combats evil by substituting knowledge for ignorance.
   c. Cultivates regard for laws and ordinances by making biological facts upon which laws are based common property of the community. Temperance laws came through the education of the public.
   d. Positive effort for good rather than repression.
   e. Making the world a better place in which to live is distinctly ethical.
   f. The producer is on the side of law and order.
2. "If boys of a neighborhood make raising of peaches and grapes impossible, a better remedy than the jail is to start them to raising peaches and grapes of their own."[5]

As biology teachers we are inclined to prefer pupils for our classes who make free choice of our subjects, however, realizing the extent to which biology contributes to the wealth of the people and to the health, efficient living and enjoyment of life of the individual, we desire to recommend that all pupils be required to take a year of a biological science in the second year of the course.

HIGHWAY AND HIGHWAY TRANSPORT EDUCATION CONFERENCE.

The United States Commissioner of Education called in Washington, D. C., on May 14 and 15, a national conference on highway and highway transport education.

The conference was attended by 70 of the leading representatives of the colleges of engineering, heads state highway departments, the automotive industries and the Bureau of Public Roads. The Educational Secretary of the Conference was Dean F. L. Bishop, of the University of Pittsburgh.

Commissioner Claxton in welcoming the members of the conference pointed out that the industrial and economic needs of today had created new demands for engineering education. At present the need for another type of engineer capable of dealing with the pressing problems of highway construction and highway transportation was becoming more and more acute.

[4]Lloyd and Bigelow, The Teaching of Biology.
[5]Hodge, Nature Study and Life.

Digitized by Google

Thomas H. MacDonald, Chief of the Bureau of Public Roads, called attention to the enormous expansion of the federal and state road building programs. These called for more and better engineers than we have been able to obtain in the past. One-fourth of all engineering students graduated annually, go into highway work.

Mr. Roy D. Chapin, President of the Hudson Motor Car Company, stated that the failure to foresee the present demands of transportation had made it impossible for the railroads to meet the demands for economical transportation especially on the short haul. This places an unusual burden on the motor truck and it makes necessary the training of men capable of dealing with all types of automotive transportation.

Doctor S. P. Capen, Director of the American Council of Education, spoke of the continued expansion of the curriculum in engineering. He warned the educators that undue specialization in highway engineering was not a sound practice and urged that more attention be given the fundamental subjects of engineering.

Doctor Walton C. John, of the Bureau of Education and Executive Secretary of the Conference, said that there are now 150 colleges and universities giving one or more courses in highway engineering. Due to the leadership of Professor Blanchard of the University of Michigan, proper recognition is expected to be given to the new subject of highway transport and cognate subjects.

The conference made definite recommendations as to the number as well as to the education of the men needed in the future by the highway constructors and automotive industries. It was also urged that the States set apart a percentage of the money appropriated for roads to be spent in suitable research in order that the money might be used to the best advantage.

The Committee on Resolutions asked the Commissioner of Education to appoint a permanent committee of 7 to continue working on the problems developed in the conference.

DR. CORNELIUS BETTEN APPOINTED VICE-DEAN OF RESIDENT INSTRUCTION.

Dr. Cornelius Betten, for the past five years secretary of the New York State College of Agriculture, has just been made vice-dean of resident instruction, the appointment to take effect July 1, 1920.

Dr. Betten is a graduate of Cornell, of the class of 1906, where he was fellow in entomology. After graduation he went to Lake Forest College at Lake Forest, Illinois, where he was professor of biology and head of the department. In 1915, he came back to his alma mater as secretary of the college of agriculture.

Under authorization of recent legislation for the college of agriculture, provision is made for three vice-deans or directors; a vice-dean of the college, a vice-director of extension, and a vice-director of the experiment station. The faculty of the college was asked to make nominations, and Dr. Betten was practically selected by his associates, the actual appointment by the trustees of the University being a ratification of the faculty's choice. Professor M. C. Burritt has been for some time vice-director of extension. The vice-director of experiment stations still remains to be chosen.

Under the present plan, Dean A. R. Mann has the aid of three vice-officers as executives in the three main branches of the work of the college; resident instruction, extension, and research.

Digitized by Google

SCIENCE QUESTIONS.

Conducted by Franklin T. Jones.

The Warner & Swasey Company, Cleveland, Ohio.

Readers are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, 10109 Wilbur Ave., S. E., Cleveland, Ohio.

Please send examination papers on any subject or from any source to the Editor of this department. *He will reciprocate by sending you such collections of questions as may interest you and be at his disposal.*

FOREIGN EXAMINATIONS.

The editor of this department desires to obtain examinations in NATURAL SCIENCE (as well as other subjects) from schools in France, Belgium, Italy, Spain, Denmark, Sweden, Norway and Finland. Any reader of SCHOOL SCIENCE AND MATHEMATICS in these countries will confer a great favor upon the editor by writing to him upon this subject.

QUESTIONS AND PROBLEMS FOR SOLUTION.

346. *Proposed by J. B. Rees, Klamath Falls, Oregon.*

In Coleman's New Laboratory Manual of Physics, Ex. 23, p. 86 (and also in many other laboratory manuals), there is given an experiment to illustrate the forces of adhesion and of cohesion. This consists in pressing two ground glass plates together and noting the force required to separate them. Cohesion is supposedly shown by having the plates wet when this is done.

(a) Is this adhesion, or cohesion?
(b) What influence has atmospheric pressure upon this experiment?
(c) What has the viscosity of the air to do with the experiment?

347. *Proposed by K. L. Pohlman, Cleveland, Ohio.*

A hammer weighing 2 pounds has a velocity of 12 feet per second at the instant it strikes the head of a nail. Find the force which the hammer exerts on the nail if it is driven into the wood 1/4 of an inch.

348. *Submitted by Wm. A. Hedrick, Central High School, Washington, D. C.*

Readers are invited to express opinions on the following list of questions:

Popular Science Monthly $5,000 Scholarship Examination.

Held throughout the United States June 2, 1920.

These questions are based upon the May, 1920, issue of The Popular Science Monthly.

Instructions.

Answer all questions. Each question has a value of 10 credits.

The candidates will be given three hours only for the examination.

Each candidate will write his name, age, name and location of his school, and his home address in the upper right hand corner of his answer paper.

The candidate will copy and sign the following declaration at the end of his examination paper

"I declare that I have neither given nor received any aid in answering the questions of this examination."

Questions.

1. (a) What makes a baseball curve? (b) Explain, in detail, the physical principles involved.

2. (a) If a boy jumped from a platform suspended from a large spring balance, what effect would this have on the reading of the balance? (b) Explain the scientific principle involved.

3. (a) Explain how daylight may be closely imitated by the use of the "checkerboard reflector." (b) How will this aid industry?

4. (a) Explain the cause of the electrolysis of gas pipes, and describe at least one way of preventing it. (b) How is electrolysis employed in electrotyping?

Digitized by Google

Textbook of Geology

By AMADEUS W. GRABAU

Recently Professor in Columbia University, now Professor in the Government University of Peking

IN this work one of the most eminent American geologists has sought to provide the standard text upon the subject for the English-speaking race. While in plan and scope the needs of college classes have been kept in view, no pains or expense have been spared in the aim to produce a work indispensable to everyone interested in the accurate and adequate presentation of the present status of the science.

Part I—General Geology. *In October.*
Part II—Historical Geology. *In December.*

D. C. HEATH & CO., Publishers

BOSTON NEW YORK CHICAGO

Back Numbers Wanted

For the following copies of SCHOOL SCIENCE AND MATHEMATICS in good condition we will pay 25 cents each: May, 1902; April, 1901; February, 1902; April, 1903; April, 1904; January, 1905; June, 1905; May, June, October and November, 1906; April, 1912 and March, 1914.

SCHOOL SCIENCE AND MATHEMATICS

2059 E. 72d Place :: :: :: CHICAGO, ILL.

"School Science and Mathematics" bears the same relation to progressive Science and Mathematics Teaching as does the "Iron Age" to the Hardware business. No up-to-date Hardware merchant does without this trade Journal. Every Science and Mathematics teacher should be a subscriber to the professional trade Journal, "School Science and Mathematics."

Please mention School Science and Mathematics when answering Advertisements.

Digitized by Google

5 (a) Explain fully how you would construct a dry-cell from tinfoil. (b) Give some causes for trouble with automobile batteries.

6. (a) With the aid of a diagram explain the construction and operation of a searchlight (b) Show how it may be made to give a parallel or a divergent beam.

7. (a) Briefly describe the considerations involved in stepping down the voltage of an electric current. (b) Explain by use of a diagram, just how you would proceed to make a transformer for stepping down 110-volts.

8. (a) What are the forces which a grand-stand designer should take into consideration for the welfare of the public? (b) To what extent should the community require the contractor to meet these factors for public safety?

9. (a) Describe a quick-action ice-cream freezer. (b) Why does the melting of the ice free e the cream? Why is salt used?

10. (a) What impressed you most in the article, "Fighting a Fire With Brains"? (b) What scientific principle is involved?

SOLUTIONS AND ANSWERS.

338. *Proposed by K. L. Pohlman, The Warner & Swasey Apprentice School. Cleveland. Ohio.*

Rectangle ABCD rests upon side AD. Side AD = 1/2AB. Coefficient of friction = 1/6. If it be pulled by a hori ontal force P at C till motion ensues, determine if it will slip on the floor, or begin to turn over round D.

(See Cut in School Science and Mathematics. April, 192", page 368.)

Solutions from Wm. R. Silvey, John Marshall High School. Richmond, Va.; N. Barotz. New York City, and H Tsai, Tangshan, North China.

Solution by H. Tsai, Tangshan Engineering College, North China.

As the motion to be produced will be either rotation or translation, let us take moments about D: then

$$P \cdot AB - W \cdot 1/2 \cdot AD = 0,$$

or

$$P \cdot AB - W \cdot 1/4 \cdot AB = 0,$$

gives

$$P = 1/4W.$$

Also the resisting friction along AD is by the law of friction

$$F = 1/6W$$

Hence any value of P greater than F = 1/6 . W (but not greater than 1/4W) will produce translation. therefore P = W/4 as force necessary to produce rotation shows at once that translation will be produced instead of rotation.

MEETING OF MOTHERS AND PARENT-TEACHERS ASSOCIATION.

The twenty-fourth annual convention of the National Congress of Mothers and Parent-Teachers Associations was held in the Assembly Room, State Capitol, Madison, Wisconsin, June 3 to 8, 1920. It was one of the largest conventions ever held and was marked by a noteworthy spirit of cooperation and progressiveness. In Wisconsin, as in many other states, the Parent-Teacher Association work is being vigorously pushed by the State Education Department.

The following officers were chosen:

President—Mrs. Milton P. Higgins, Worcester, Massachusetts.

Corresponding Secretary—Mrs. George B. Chandler, Rocky Hill, Connecticut.

Recording Secretary—Mrs. Joseph Garibaldi, Charlotte, N. C.

Treasurer—Mrs. Hubert N. Rowell, Berkeley, California.

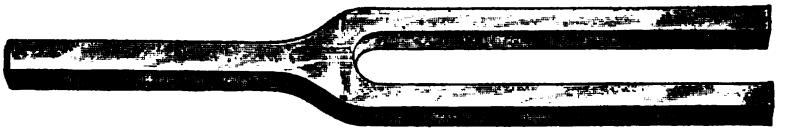
Auditor—Mrs. Charles H. Remington, East Providence, R. I.

Historian—Mrs. Giles Scott Rafter, Washington, D. C.

Reports showed an increase in membership for the year, April, 1919, to April, 1920, of more than 90,000. The total membership today is over 218,000. The goal for the coming year is 1,000,000 members.

Digitized by Google

TUNING FORKS



Designed especially for 'Student's Laboratory use. They are made in one piece, being cut from solid steel bars to insure the proper rigidity and elasticity for producing the best results. Accuracy to within one vibration.

C	128 Double Vibrations, 10 in. long	$3.95			
C_1	256 D. V., 7 ½ in.	$2.55	G_1	384 D. V., 7 ½ in.	2.40
D_1	288 D. V., 6¾ in.	2.55	A_1	426 D. V., 6 in.	2.30
E_1	320 D. V., 7 in.	2.45	B_1	480 D. V., 5¾ in.	2.25
F_1	341 D. V., 6¾ in.	2.40	C_2	512 D. V., 6¼ in.	2.25

Catalog S-20 lists a complete line of Scientific Apparatus and Supplies. Send for your copy NOW

E.W.A.ROWLES CO.

·MANUFACTURERS·

SCHOOL FURNITURE AND SUPPLIES

2345-51 SO. LA SALLE ST.

CHICAGO, ILL.

ARTICLES IN CURRENT PERIODICALS.

American Mathematical Monthly, for July-September; *Lancaster, Pa.; $4.00 per year, 50 cents a copy:* "April Meeting of the Kansas Section," H. E. Jordan; "April Meeting of the Kentucky Section," G. W. Smith; "Fifth Annual Meeting of the Ohio Section," G. N. Armstrong; "April Meeting of the Rocky Mountain Section," G. H. Light; "Mathematics and Life Insurance," Mr. P. C. H. Papps; "Note on the Roots of the Derivative of a Polynomial," W. H. Echols; "Questions and Discussions: Questions—Replies to Question 34," E. Swift, A. A. Bennett and W. A. Hurwitz; "Discussions—Notes on Curves Whose Evolutes Are Similar Curves," G. H. Light; "Functions of Half-Angles of a Triangle," R. D. Bohannan; "The Use of the Vector in Analytic Geometry," V. C. Poor.

American Journal of Botany, for July; *Brooklyn Botanic Garden, Brooklyn, N. Y.; $6.00 per year, 75 cents a copy:* "Measurement of the Catalytic Power of Catalase," L. G. M. Baas Becking and H. C. Hampton; "Early Stages in the Development of Certain Pachypsylla Galls on Celtis," B. W. Wells; "The Upward Translocation of Foods in Woody Plants. II. Is There Normally an Upward Transfer of Storage Foods from the Roots or Trunk to the Growing Shoots?" Otis F. Curtis; "Early Stages in the Development of the Sporophyte of Sphagnum Subsecundum," Geo. S. Bryan.

Condor, for July-August; *Eagle Rock, Los Angeles Co., Calif.; $2.00 per year, 40 cents a copy:* "In Memoriam: Frank Slater Daggett (with portrait)," H. S. Swarth; "Variations in the Song of the Golden-crowned Sparrow (with 4 figures)," Frank N. Bassett: "Additional Notes on the Avifauna of Forrester Island, Alaska," George Willett; "Observations on the Habits of the White-winged Dove," Alexander Wetmore; "A New Ptarmigan from Mount Rainier (with 3 photos)," Walter P. Taylor; "The Californian Race of the Brewer Blackbird," J. Grinnell; "Notes From Field and Study."

National Geographic Magazine, for August; *Washington, D. C.; $3.50 per year, 35 cents a copy:* "Antioch the Glorious" (21 illustrations), William H. Hall; "The Origin of American State Names" (34 illustrations), Frederick W. Lawrence; "The Channel Islands" (25 illustrations), Edith Carey.

Digitized by Google

Photo-Era, for August; *Boston, Mass.; $2.50 per year, 25 cents a copy:* "True Sepias," Frank B. Howe; "Landscapes with Figures," George W. French; "Warnings to the Photo-Salesman," Charles G. Willoughby; "An Amateur's Confession," Enoch M. Barker; "Sunlight-Portraiture," A. H. Wood; "How Lenses Are Made," Wiener Mitteilungen; "Photographing an Old English House," Carine and Will Cadby; "The Danger of Inadequate Fixation," Wilfred A. French, Ph.D.; "Locally Printing-Up Dense Highlights," The British Journal; "An Historical Parallel in Portraiture," Wilfred A. French, Ph.D.

Physical Review, for August; *Ithaca, N. Y.; $7.00 per year, 75 cents a copy:* "The Existence of Homogeneous Groups of Large Ions," Oswald Blackwood; "Electrical Discharges from Pointed Conductors," John Zeleny; "Some Physical Properties of Nickel-Iron Alloys," L. R. Ingersoll and Others; "The Selective Reflection of Heat Waves by Linear Resonators," E. C. Wente; "The Crystal Structure of Sodium Nitrate," Ralph W. G. Wyckoff; "A Note on the Correction of Contact Difference of Potential Developed in Compton's Modification of the Quadrant Electrometer," Otto Stuhlman, Jr.; "Note on the Electromagnetic Force Between Two Atoms," G. A. Schott.

Popular Astronomy, for August-September; *Northfield, Minn.; $4.00 per year:* "John Alfred Brashear, 1840-1920" (with Plate XIX), Frank Schlesinger; "South of the Equator," S. C. Hunter; "To the Amateur Observer," Miss Elizabeth Emory; "Aitoff's Equal-Area Projection of the Sphere," R. L. Faris; "Note on the Temperature of the Earth's Interior," William O. Beal; "The Conon Bradley Snow Fields," William H. Pickering; "Tidal Action," F. J. B. Cordeiro; "The Solar Eclipse of 1920, November 10, as Visible in the United States," William F. Rigge.

Popular Science Monthly, for August; *Modern Publishing Co., New York; $3.00 per year, 25 cents a copy:* "How Much Gas Can You Breathe?" "Tomorrow's Weather"; "The Greatest Sea Fighter of Them All"; "Surgeon to Worn-Out Documents and Books"; "A Fire Engine to Raise Sunken Treasure"; "Carrying the Power on a Separate Boat"; "Unloading Thirty Railroad Cars in An Hour"; "Carrying Perishables in Refrigerator Trucks."

Scientific Monthly, for September; *Garrison, N. Y.; $5.00 per year, 50 cents a copy:* "The poem of the Philosopher Theophrastos upon the Sacred Art—A Metrical Translation with Comments upon the History of Alchemy," Dr. C. A. Browne; "The Economic Problem of the Ozark Highland," Carl O. Sauer; "Giant Suns," H. H. Turner; "The Medical and Allied Professions as a State Service," Dr. D. F. Harris; "The Economic Importance of the Scientific Work of the Government," Dr. Edward B. Rosa; "Democracy's Opportunity," Dr. Stewart Paton; "The Methods of Procedure in the Analysis of Heredity," Charles Zeleny; "A Simplified Musical Notation," Edward V. Huntington.

Torreya, for May-June; *Brooklyn Botanic Garden, Brooklyn, N. Y.; $1.00 per year, 30 cents a copy:* "Additions to the Flora of Western Oregon During 1919," J. C. Nelson; "Length of Day and Flowering and Fruiting"; "Pin Oak in Nebraska," Raymond J. Pool.

C. G. CAMPBELL HEADS KEWAUNEE COMPANY.

C. G. Campbell, well known throughout the United States as an expert in the manufacture and sale of laboratory furniture, has been elected a member of the Board of Directors and appointed General Manager of the Kewaunee Manufacturing Company, Kewaunee, Wisconsin.

Mr. Campbell is well known to many school executives on account of his connection of several years as sales manager of the Kewaunee Manufacturing Company.

The Kewaunee Manufacturing Company is one of the oldest manufacturers in the country of laboratory equipment for schools, hospitals, manufacturing plants, etc., and enjoys a deservedly high reputation for the excellence of its product.

Digitized by Google

Announcement

THE Board of Directors of the Kewaunee Manufacturing Company announce the election of Mr. C. G. CAMPBELL as a Director and General Manager of this Company. Mr. Campbell was for several years associated with us as Sales Manager.

The Directors also wish to announce that Mr. F. H. WIESE is no longer associated with the Kewaunee Manufacturing Company as General Manager and Secretary, or in any official capacity.

The Kewaunee Manufacturing Company, Kewaunee, Wisconsin, is not associated in any manner with any other manufacturer of laboratory furniture or equipment now operating or organizing.

We are in position to take care of the requirements of our trade and have ample facilities for making prompt shipments of our standard line and special equipment consistent with the time required to manufacture.

Thanking you for your past patronage and the continuance of your business, we are

Cordially yours,

Kewaunee Mfg. Co.

LABORATORY FURNITURE EXPERTS

KEWAUNEE, WIS.

C. G. CAMPBELL, *Gen. Mgr.*
L. W. BRUEMMER, *Sec'y.*
J. L. HANEY, *Pres., Treas.*
G. A. DUVALL, *Vice Pres.*

Please mention School Science and Mathematics when answering Advertisements.

Digitized by Google

JOHN LOSSEN PRICER IN HIS RELATION TO NATURAL SCIENCE.

By H. J. Van Cleave,
University of Illinois.

No one of the younger men of this generation has had a more wholesome or a more profound influence in the solution of the problems relating to natural science in our middle-western public schools than has John Lossen Pricer. Because of his active participation in the various educational and scientific organizations and institutions of this state, his death will be especially keenly felt by his coworkers in Illinois.[1]

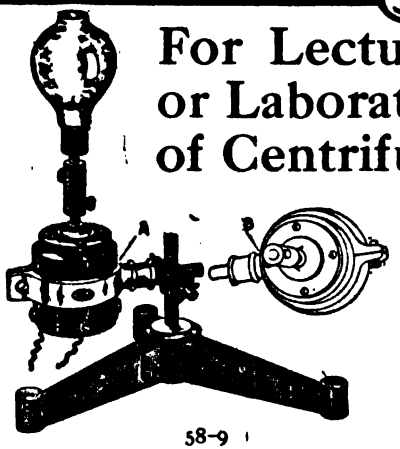
In 1907 Mr. Pricer received both the A. B. and the A. M. degrees from the University of Illinois, then after two years as principal of the Marshall Township High School he returned for one year to the University of Illinois as an assistant in botany. At the end of that year of study he accepted the position as professor of biology at the Illinois State Normal University, where he became one of the most influential members of the faculty and a highly esteemed citizen. Much of the development of the Senior College in that institution was made possible because of the untiring manner in which he as a member of the committee insisted upon the erecting of suitable standards and the convincing of other institutions that these standards were being maintained.

His training and his work brought him into intimate relationship with an unusually large number of different aspects of the educational system. This diversity of experiences naturally fitted him for an unparalleled understanding of the educational problems pertaining to the field of his major interest, the natural sciences. It is not surprising, then, that he became a worthy successor of men like S. A. Forbes and J. M. Coulter in the active leadership of shaping the general educational policies of the secondary schools of the state in matters relating to the teaching of biological sciences. His activity in this direction found its fullest expression through the meetings and the publications of the State High School Conference. His invariably lucid analysis of a problem, his persuasive presentation, and his decided sincerity always assured for him an audience of appreciative hearers, many of whom were glad to profit by his wealth of suggestions.

During the past four years Professor Pricer served the Illinois State Academy of Science as its secretary. An examination of the Academy programs during this period reveals a strong emphasis upon educational and public health problems, in great measure due to his ardent desire to keep before the people of the state the necessity of more thorough knowledge of science as a requisite to good citizenship.

Through his exceptional ability as a teacher, he has trained many teachers who have studied under him and have partaken of his zeal in the advancement of the cause of science. Yet his ardor for teaching never deadened his sincere appreciation for the new in science. Frequently he would refer to his student days and recall the supreme joy of discovery that came to him when in the course of his investigation he first realized that he had unearthed a truth concerning nature about which the entire world previously had been ignorant. In spite of this fascination with which he viewed the results of original investigation, he saw that his varied experiences had offered to him a peculiar opportunity to serve the cause of science through devoting his life to a study of the problems concerning science teaching. Problems such as he attacked are frequently shunned by others because of the realization of

Digitized by Google



For Lecture Demonstration, or Laboratory Application, of Centrifugal Force . . . . .

58-9

The Waverley-Electric Specifications

Support—Standard Tripod.
Yoke—Cast Aluminum.
Housing—Enameled Iron.
Motor—6,000 R. P. M.
Mica Insulation. Self-Adjusting Brushes.
Ball-Bearing Shaft.
Current—D. C., A. C., or Dry Cells.
Chuck—Universal.

You Need This Waverley Electric—
A Whirling Machine and Centrifuge Combined.

As a whirling machine the Waverley-Electric takes a Centrifugal Globe (as illustrated), or Double Hoops, Centrifugal Balls, and other accessories.

A Centrifuge Head converts the Waverley-Electric into a powerful centrifuge that may be used with efficacy for the analysis of milk, urine, blood, or other liquids.

The specially designed, ball-bearing motor is mounted and balanced to operate in vertical or horizontal position. Consequently its general utility includes the rotation of Savart's Wheels, Siren Discs, Newton's Color Discs and the like.

58-9 **The Waverley-Electric, including Support Yoke, Motor and Chuck.....$19.00**
58-9a **Waverley Centrifuge Head, four-arm. 3.75**

Cambridge Botanical Supply Company

LABORATORY EQUIPMENT—ALL SCIENCES

1-9 Lexington Street **1884-1920** **Waverley, Mass.**

Blakiston

A Blakiston Textbook will change the school atmosphere from cold indifference to warm enthusiasm

NEUFELD'S

With a Table of Logarithms

Elementary Algebra

— By J. E. Neufeld —

Central High School, Philadelphia

It is the text that makes only a memory that frequent and troubl some remark of the student "I couldn't understand the explanation in the book."

It is an Illustrated Algebra.

Cloth, $1.45 Postpaid

P. BLAKISTON'S SON & CO.

Publishers - Philadelphia

Digitized by Google

the fact that they are too big for one man to solve alone, yet he was content to invest his energy and his ability in the hope of contributing something toward their solution. Those who knew most intimately of his work know that he gave much and only regret that he could not be allowed a few more years to round out some of the many things he had so well in hand at the time of his death.

John Lossen Pricer was born January 10, 1871. While looking after business interests in Risco, Mo., he died very unexpectedly on August 19, 1920. For some months he had been subject to heart trouble, a recurrence of which caused his death practically without warning.

BOOKS RECEIVED.

Laboratory Manual of Elementary Colloid Chemistry, by Emil Hatschek, London, Eng. Pages viii+135. 12.5×19 cm. Cloth. 1920. $2.00 net. P. Blakiston's Son and Co., Philadelphia.

Lighting from Concealed Sources, by J. L. Starr, Chief Engineer, National X-Ray Reflector Company. 246 pages. 21×26 cm. Cloth. 1919. Chicago.

Teacher Training Departments in Minnesota High Schools, by Lotus D. Coffman, Dean of the School of Education, University of Minnesota. Pages viii+92. 13×20 cm. Paper. 1920. General Education Board, 61 Broadway, New York City.

What Will Metric Standardization Cost? World Trade Club, 148 pages. 9×21.5 cm. Paper. 1920. 50 cents. World Trade Club, San Francisco, Calif.

The High School Boy and His Problems, by Thomas Arkle Clark, Dean of Men, University of Illinois, Urbana. 194 pages. 13×20.5 cm. Cloth. 1920. The Macmillan Company, New York.

Elementary Applied Mathematics, by W. Paul Webber, University of Pittsburgh. Pages ix+115. 13.5×21 cm. Cloth. 1920. John Wiley and Sons. New York City.

The Individual and the Curriculum, Experiments in Adaptation, by the Faculty of the Francis W. Parker School. 161 pages. 15×23 cm. Paper. 1920. 45 cents. The Frances W. Parker School, Chicago.

The Professional Preparation of Teachers for American Public Schools. Bulletin 14, by William S. Learned, William C. Bagley and others. Pages xix+475. 19×25 cm. Paper. 1920. The Carnegie Foundation, 576 Fifth Avenue, New York City.

Practical Chemistry, by N. Henry Black, Roxbury Latin School, Boston, and James B. Conant, Harvard University. Pages x+474. 13×19 cm. Cloth. 1920. The Macmillan Company, New York City.

Practical Physics by Robert A. Millikan and Henry G. Gale. University of Chicago. Revised edition. Pages x+462, 13×19 cm. Cloth. 1920. $1.64. Ginn & Co., Boston.

Animal Husbandry, by John L. Forney and Rolla C. Lowry, University of Wisconsin. 351 pages. 13×19 cm. Cloth. 1920. American Book Co., New York City.

Vocational Arithmetic, by Clarence E. Paddock, Wentworth Institute, Boston, and Edward E. Holton, Technical High School, Springfield, Mass. Pages x+232. 12.5×18.5 cm. Cloth. 1920. D. Appleton & Company, New York.

Heredity and Evolution in Plants, by C. Stuart Gager, Director of the Brooklyn Botanic Garden. Pages xv+265. 113 illustrations. 14×20 cm. Cloth. 1920. P. Blakiston's Son & Company, Philadelphia, Pa.

Bulletin No. 11, Statistics of State School Systems, by H. R. Bonner,

Digitized by Google

An Elementary General Science

By DANIEL RUSSELL HODGDON, Sc. D., LL. D.

Pres. of Valparaiso University, Valparaiso, Ind. Former Pres. of Hahnemann Medical College & Hospital of Chicago. College of Technology, and Director School of Technology, Newark, Lecturer Newark Institute of Arts and Science, and Member of the Faculty of New York University and New Jersey State Normal School.

559 pages. 440 illustrations, $1.75.

This book has been prepared for the Junior High School and the first years of High School.

Unlike every other book on this subject, the material of the ELEMENTARY GENERAL SCIENCE is organized around one central theme—THE HOME.

Noteworthy Features of the Book

1. The subject matter is splendidly organized—a logical arrangement and a teachable sequence of topics.
2. The style is always within the comprehension of the high-school student.
3. The course is so flexible as to be easily adjusted to the needs of any class. The book may be covered in one term or in two.
4. The inclusion of over 100 experiments eliminates the necessity of the additional expense of a Laboratory Manual.
5. The "Socialized." "Project" and "Problem" methods form the backbone of the lesson presentations.
6. It is the *ONLY* GENERAL SCIENCE which takes up the subjects of Safety Precautions and Emergency Treatments.
7. The book contains over 400 ILLUSTRATIONS and more than 1000 THOUGHT AND FACT QUESTIONS!

Junior General Science

FOR THE GRADES

By DANIEL RUSSELL HODGDON, Sc. D., LL. D.

340 pages, $1.25.

Our Grade Schools must prepare pupils to think and reason in the environment in which they live. This is the demand of the present age, to better understand the world.

The author's experience in grade teaching and supervising grade instruction has prepared him to write a usable book expressed in understandable language. The many thought questions provide for individuality on the part of the pupil.

HINDS, HAYDEN & ELDREDGE, Inc.

New York **Philadelphia** **Chicago**

Digitized by Google

Department of the Interior. 155 pages. 30 cents. Government Printing Office, Washington, D. C.

Bulletin No. 63, Natural Science Teaching in Great Britain, by Committee appointed by the Prime Minister. 106 pages. 14.5×23. Paper. 1920. 15 cents. Government Printing Office, Washington, D. C.

The American Red Cross in the Great War, by Henry P. Davidson, Chairman of the War Council of the American Red Cross. 302 pages, 13.5×19.5 cm. Cloth. 1920. The Macmillan Company, New York.

Introduction to Vocational Education, by David S. Hill, President of the University of New Mexico. Pages xvii+483. 13.5×19.5 cm. Cloth. 1920. $2.00. The Macmillan Company, New York.

Modern Junior Mathematics, Book Three, by Marie Gugle, Assistant of Schools, Columbus, Ohio. Pages xiii+246. 13.5×19 cm. Cloth. 1920. $1.00. The Gregg Publishing Company, 77 Madison Ave., New York.

Dietetics for High Schools, by Florence Willard, Washington Irving High School, New York, and Lucy H. Gillett, Boston, Mass. Pages xx+201. 13×19.5 cm. Cloth. 1920. The Macmillan Company, New York.

Elements of Physics, by R. A. Houstoun, University of Glasgow. Pages viii+221, 202 figures. 14.5×22. Cloth. 1919. $1.90. Longmans, Green & Company, New York City.

BOOK REVIEWS.

Armenia and the Armenians, by Kevork Aslan, translated for the French by Pierre Crabites. Pages xxix+138. 13.5×20 cm. Cloth. 1920. The Macmillan Co., New York City.

In these strenuous times, especially applied to Armenia, this book is very timely. It gives a history of Armenia and the Armenian people from the earliest times down to the beginning of the Great War, in 1914. The author is an Armenian who is perfectly familiar with the history of his people, and to Americans who wish to become more familiar with the trials and tribulations through which the Armenians have passed, they could not do better than to secure a copy of this book. The author has made profuse use of other texts bearing upon the history of these folk. With this little book as a guide, one would be able to become familiar with the entire literature of the Armenian people.

It is printed on uncalendered paper, which makes it quite easy to read.

C. H. S.

Zoology, a Textbook for Colleges and Universities, by T. D. A. Cockerell, Professor of Zoology, University of Colorado. Cloth. xii+568 pages. Illustrated with maps, charts, drawings, and photographs. Price $3.00. Yonkers-on-Hudson, New York, World Book Company.

This text is rather a unique college course because it stresses the cultural side of Zoology rather than the educational one. It is surprisingly deficient in the details on Anatomy and Embryology commonly found in higher texts, and for those courses which aim to develop the highly trained and skillful technician the book is unfitted. For example: Protozoa as a phylum are discussed in the brief limit of seven pages, one-third of which is illustration. The classic clam is pictured and described within one and one-half pages, and this text is descriptive of the shell exclusively. But Protozoa later becomes a subject of a chapter upon heredity and of another chapter upon disease. Such treatment occurs again and again within the book. The modern problems centering about the Chromosomes, those referring to heredity, sex, genetics, and society

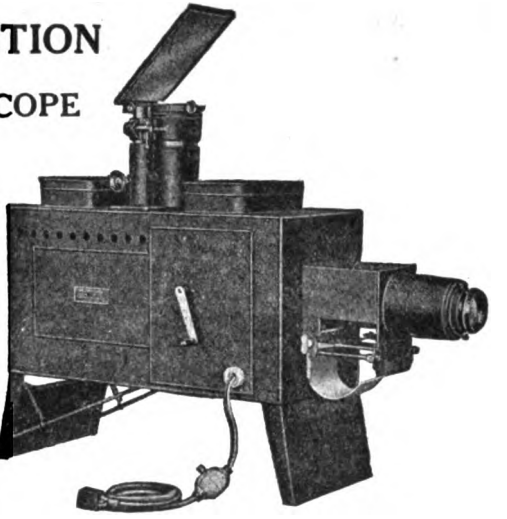
Digitized by Google

VISUAL INSTRUCTION
WITH
SPENCER DELINEASCOPE MODEL 3

is made perfect because it is an IDEAL STEREOPTICON for both lantern slides and opaque objects, such as pictures, post-cards, reading matter and objects of all kinds dead and alive.

IDEAL, because it embodies basic ideas (patented) possessed by no other. Example: Mechanical means of handling the slides, which does away with the antiquated lantern-slide holder and at the same time gives a "dissolving effect" on the screen unattained with other outfits except by using two stereopticons, one above the other.

One Spencer Delineascope does it.



Spencers Delineascope Model 3 for both lantern slides and opaque objects. 1,000 Watt Masda bulb illuminant. **Price, $185.00**

SPENCER BUFFALO U.S.A.

SPENCER LENS COMPANY
Buffalo, New York

Manufacturers of **Microscopes, Microtomes, Delineascopes, Optical Glass, Scientific Apparatus, Etc.**

SPENCER BUFFALO U.S.A.

No. 2402

We Carry a Complete Stock of

Chemicals & Apparatus

for the

Physical
Agricultural
Chemical
Biological
Laboratory

We Excel in Equipping High School Laboratories.
Let Us Quote Prices on Your Next List of Requirements.

THE KAUFFMAN-LATTIMER CO.

41 East Chestnut Street
Columbus, Ohio

Digitized by Google

are well treated. The story of early man is told in the language of very recent investigation. Geographical distribution is given fairly ample treatment, and scattered throughout the book are some very fine biographies, those of Agassiz, Pasteur, Fabre, and others.

The reviewer is of the candid opinion that the use of this book might prove a very beneficial change in the routine of some colleges where crystallization has set in. It would, in this environment, be very much disliked and yet it might work as a leaven to overcome this bias in the course and in the professor. Continued use of such a text as this would doubtless popularize the zoology department, and yet it would not produce any highly trained students unless it were supplemented by a very exacting laboratory course, or succeeding courses, of the old line character.

We welcome the appearance of such a text with the hope that it may bring about a revival of interest in Zoology and add an extension of Zoological teaching in the American Commonwealth. H. B. S.

General Botany, by H. D. Densmore, Professor of Botany in Beloit College. 459 pp. 289 fig. Ginn and Co. 1920.

This is a wholly new botany course. The plan is new, the method of treatment is new, the illustrations are nearly all new. It is the embodiment of the present day desire to present the plant as a living active organism, getting its food and force from the environment.

The plant is described first as a creature with a hereditary body organization or plan. With its hereditary organs it responds to environmental influences in an adaptive way. For an understanding of these organs and adjustments, cellular structure is next described. Growth is studied as an expression of cell activity. Chapter VI presents the structure of stems, roots and leaves. Stem structure is here for the first time presented in its modern aspect, viz. the woody stem as primitive, from which is derived the herbaceous dicot and finally the monocot. Probably no one doubts that this is the evolutionary sequence. No one who has tried teaching it to beginners in this order will doubt that the presentation is at once easy and logical and satisfying.

Section III treats of physiology. Photosynthesis, digestion, assimilation, and respiration are concisely and clearly outlined. Here Professor Densmore has introduced a summary of the whole discussion up to this point under the caption "Seasonal Life of the Plant." He outlines the entire nutritive relation of the plant from the germination of the seed until it again produces seed. The annual bean, the biennial white sweet clover, and the perennial herb and tree (locust) are used as examples. This is a very striking review of the life of the plant. Absorption, conduction and transpiration of water are next described.

Section IV gives vegetative and sexual reproduction in flowering plants, followed by a clear statement of the work of Darwin and Mendel in plant breeding.

Part II gives the usual series of life-histories. A unique feature here is the emphasis on ecological relations. The descriptions of alternation of generations in ferns, gymnosperms and angiosperms are very well worked out and especially well illustrated. Stem anatomy of ferns and gymnosperms is also well portrayed. The doctrine of leaf-gaps is fully presented.

Part III gives "Representative Families and Species of the Spring Flora." Our common trees are described and illustrated. Taxonomic, ecologic, sylvic and economic characteristics are discussed. Thirteen of the more prominent families of flowering herbs are described and illustrated.

Digitized by Google

EVERY-DAY SCIENCE

is the modern idea—science that explains every-day phenomena in terms that bring it well within the child's range.

MILLIKAN AND GALE'S Practical Physics

A new book as up-to-the minute in its emphasis on the practical side of science as in its clear and comprehensible explanations of the tank, the submarine, the aeroplane and the wireless telephone. An extraordinarily beautiful book, illustrated by two new full-page color plates and a large number of halftones, drawings and diagrams.

GINN AND COMPANY

BOSTON NEW YORK CHICAGO LONDON
ATLANTA DALLAS COLUMBUS SAN FRANCISCO

Questions For Reviews

75,000 Already Sold

Compiled from Recent College Entrance Examinations

Separate pamphlets. Price 40 cents each. Liberal discounts on quantity orders. Sample copy half price. Copy for teacher free on adoption for class use Answers to numerical problems can be supplied to teachers only. Prices on application.

Algebra
Chemistry
Physics

By Franklin T. Jones

Plane Geometry
Solid Geometry
Trigonometry

French A, and B; German A, and B;
English; First, and Second Latin;
Question Book on History (Greek, Roman, American, English)
Medieval and Modern European History

Write for prices and information

University Supply & Book Company

Digitized by Google

The book is avowedly brief and concise. It is intended for the use of beginning classes in colleges and universities, and can follow any of the high school botany courses now given. For a half year course, pages 1-212 give an excellent unit. Instead of giving a mass of material from which the teacher must select, it gives a minimum, and that of the most clear cut, universally accepted material. Upon this the teacher may build in any way and to any extent. It is expected that pupils will use the text in the laboratory, reading appropriate portions while the specimens are in hand. A laboratory guide is promised this fall. This will have references to the text and copious questions for the pupil to answer as he examines his specimen.

While this book in this edition is not free from errors of text and figure it is the only really modern botany that has yet appeared. It is to be hoped that a new edition will soon be called for, wherein minor corrections can be made. H. S. C.

Experimental Organic Chemistry, by Augustus P. West, Ph.D., Professor of Chemistry, University of the Philippines. First edition, pp. xiii+469. Illustrated with drawings and diagrams. Cloth. 1920. $3.00. World Book Co., Yonkers-on-Hudson, N. Y.

A new departure, in that it consolidates in one volume a laboratory manual of organic chemistry and an abridged textbook. This new contribution to our chemical literature has many novel and commendable features.

Among the noteworthy improvements in method of teaching which appear in the book one of the most marked is the careful correlation of the facts in regard to comparable aliphatic and aromatic compounds. Students as a rule do not themselves apply their knowledge of the aliphatic compounds to similar aromatic compounds; they may not even recognize the similarity until it is pointed out to them. Hence it is good pedagogy to call attention to resemblances and differences and to force a recalling and a use of previously acquired knowledge. This thing is well done in the new manual in question.

Another well handled matter is the graphic formula. Frequent tabulation of such formulas in full page tables gives a chance for direct comparison of the structures of similar substances.

The directions for performing the experiments are exceptionally clear and concise, perhaps because of much revision of mimeographed instructions used by the author while the book was in process of preparation.

The manual gives over one hundred experiments.

Applications and uses of many of the more important compounds are briefly touched upon and commercial methods of preparation of a considerable number of them are well given.

While the college teacher of experience may well work up his own textbook and laboratory manual, as Professor West has done, the many younger men will find in this new book a workable manual for a laboratory course to accompany or to follow a lecture course in organic chemistry.

F. R. W.

Laboratory Manual of Elementary Colloid Chemistry, by Emil Hatschek. First edition, pp. viii+135. 1.5×12.7×18.7 cm. 20 illustrations. Cloth. 1920. $2.00 net. P. Blakiston's Son and Co., Philadelphia.

This little manual attempts to provide for the laboratory study of colloid chemistry the equivalent of the regulation laboratory manual in the older established courses in chemistry.

It gives accurate and very detailed directions for carrying out the

Digitized by Google

Modern Junior Mathematics

By MARIE GUGLE

Assistant Superintendent of Schools, Columbus, Ohio

A three-book series for seventh, eighth, and ninth grades or junior high schools.

A practicable and workable plan for teaching correlated mathematics.

The pupil who has completed this series, will have acquired a definite idea of the part mathematics plays in the affairs of men in the workaday world.

He will have made a limited survey of the complete elementary field.

He will have acquired an understanding of many mathematical tools, and masterly skill in the use of them.

His knowledge of these tools and their uses will be so broad that whenever later need arises, whether in the drafting room, the shop, the factory, or senior high school, he will know what he needs or how to find it.

AUTHORITATIVE OPINIONS

The books are excellent. I wish I were a boy again to study mathematics with their aid.—*A District Superintendent of Schools*, New York City.

The texts appeal to me as a distinct contribution of value to this field. The material is live and interesting and valuable.—Louis C. Karpinski, *Associate Professor of Mathematics*, University of Michigan.

The books have many new elements which will appear startling to the conservative teacher, but should be accepted by the progressive at once.—"School," New York City.

I want to pronounce the verdict of "well done" upon Modern Junior Mathematics. The series is very much to my liking. Your correlation of number and space in the second book is unique.—*Professor of Mathematics*, a well-known Normal School.

Recently approved by the California State Board of Education and by the North Carolina State Text Book Commission

Before adopting a general mathematics text examine Modern Junior Mathematics. Send to our nearest office for sample copies. Book I, II and III. Prices 80 cts., 90 cts. and $1.00 respectively.

THE GREGG PUBLISHING COMPANY

NEW YORK CHICAGO BOSTON SAN FRANCISCO

Digitized by Google

fundamental operations, for making a number of representative preparations, and for examining them by the standard methods.

That the reader of this review may know the subjects treated the chapter headings are appended.

Chap. I, General Remarks on Apparatus, Materials and Procedure. Chap. II, Dialysis. Chap. III, Suspensoid Sols. Chap. IV, Suspensiors. Chap. V, Organosols. Chap. VI, Emulsoid Sols and Cels. Chap. VII, Egg Albumin Sol. Chap. VIII, Emulsions. Chap. IX, Ultra Filtration. Chap. X, Optical Methods of Examination. Chap. XI, Cataphoresis. Chap. XII, Electrolyte Precipitation of Suspensoid Sols. Chap. XIII, Mutual Precipitation of Suspensoid Sols. Chap. XIV, Protection. Chap. XV, Viscosity Measurements. Chap. XVI, Adsorption (Qualitative Exps.). Chap. XVII, Capillary Analysis. Chap. XVIII, Determination of an Adsorption Isotherm. Chap. XIX, The Siesegang Phenomenon.

A number of references to the literature follow each chapter.

The manual should be added to all chemical libraries even though no formal course in laboratory colloid chemistry is contemplated, for it should prove useful to anyone who is reading any text on the principles of colloid chemistry, as such texts seldom give sufficient detail in their accounts of the experiments cited by way of illustration.

F. B. W.

The High School Boy and his Problems, by Thomas A. Clarke, dean of Men at University of Illinois. Pages vii+194. 13.5×19.5 cm. Cloth. 1920. Macmillan Co., New York City.

There are few men better equipped to write on this subject than the author of this book. It is one of the best books of its kind that has ever been published. It goes directly to the core of the matter and presents the problem of the boy with which parents and teachers have to deal in a most forcible manner, making suggestions and explaining how it is best to deal with all types of boys. His knowledge is gained by intimate contact with thousands of high school fellows as well as college men and thus enables him to present his views in a most convincing manner.

The book surely will be immensely helpful to all those who are dealing with boys. The parent, too should read the book, likewise the boy, as he may be convinced, if inclined to go the wrong way, that from all points of view it is best for him to follow the precepts laid down for him in the book.

This book makes good reading for any and every one; it is splendidly written, fascinating, and to the point. It deals with all phases of a boy's life and should be in the library of every home. It deserves and undoubtedly will have a wide circulation.

C. H. S.

What Will Metric Standardization Cost, by The World Trade Club. 148 pages. 9+22 cm. Paper. $0.50. 1920. The World Trade Club, 681 Market St., San Francisco, California.

This is a splendid compilation of the views of influential men and corporations concerning the universal adoption of the metric system of measurements. The World Trade Club deserves encouragement for the tremendous efforts they are making towards the adoption of the only kind of measurements worthy of consideration in a civilized nation. All readers of this journal should possess themselves with a copy of this interesting book and themselves do everything to promote the efforts that are being made for the adoption of the metric system. This journal has always stood and worked for this system and was one of the pioneers of 20 years ago in advocating the universal adoption of this system of measurements.

C. H. S.

Digitized by Google

Leonard Peterson & Co. *Inc.*

Pioneer Designers and Manufacturers of

High Grade Laboratory Furniture

For Chemistry, Physics, Biology, Physiography, Domestic Science, Domestic Art, and Manual Training.

Instructor's Table No. 1205

Superior quality, strength, solidity, and durability are built right into our furniture. Every detail is well worked out. Our furniture has met with the approval of hundreds of educators thruout the United States, Canada, Porto Rico, and China.

Send for a copy of our general catalog No. 10.

Leonard Peterson & Co., Inc., 1234-48 Fullerton Ave., Chicago

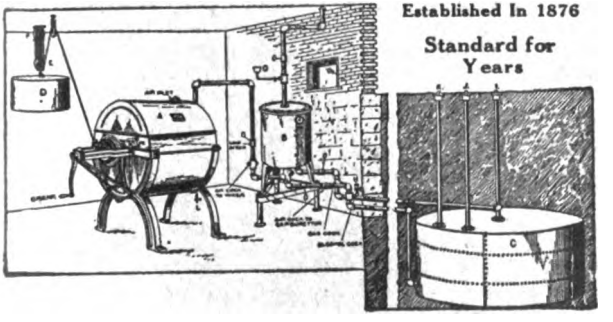
MANUFACTURERS OF GUARANTEED LABORATORY FURNITURE

New York Office: Grand Central Palace, New York City

Back numbers of School Science, School Mathematics, and School Science and Mathematics may be had for 30 cents a single copy. The Mathematical Supplements for 15 cents a copy.

In sets the prices are, postpaid:

School Mathematics and Supplements, Vol. I, five numbers	$1.00
School Science, Vol. I, eight numbers	6.00
School Science, Vols. II and III, each	6.00
School Science, Vol. IV, three numbers	.75
School Science and Mathematics, Vols. V, VI, VII, VIII, IX X, XI, XII, XIII, XIV, XV, XVI and XVII, each	2.00
School Science and Mathematics, Vols. XVIII and XIX	2.50



Established In 1876

Standard for Years

This Machine Will Produce

Automatically

GAS

For your laboratories, Domestic Science Department and for lighting.

* * *

In use in hundreds of educational institutions throughout the country.

Write to us for a list of colleges and high schools using our machine.
Illustrated Catalogue Will be Sent on Request.

MATTHEWS GAS MACHINE CO.

180 N. Dearborn Street, CHICAGO, ILLINOIS

Digitized by Google

Second Course in Algebra, by W. B. Ford, Professor of Mathematics in the University of Michigan, and Charles Ammerman, the William McKinley High School, St. Louis. Pages ix+299. 13×19 cm. $1.28. 1920. The Macmillan Company, New York.

The first part of the book gives a review of the first course through quadratic equations. The method of treatment is largely inductive, being based upon solved problems and other illustrative material rather than upon any attempt at proof or formal demonstration. Part II presents the usual topics of the advanced course with excellent lists of problems and thorough explanations of the more difficult topics. The table of powers and roots give an opportunity for the pupils to learn how to use tables, which they will find to be a great advantage in technical pursuits. H. E. C.

Number by Development, Vol. III, Grammar Grades, by John C. Gray, A. M., Superintendent of Schools, Chicopee, Mass. Pages xx+514. 13×19 cm. 1919. J. B. Lippincott Company, Philadelphia.

The purpose of this volume is to offer to the teacher outlines in detail of the teaching steps in decimal fractions, percentage, interest and its applications, and average, so that she may be able to conduct her work steadily and consistently on a logically arranged development plan. The method of solving problems in percentage by the use of diagrams is of considerable interest and should help the pupils to master this rather difficult topic. At the conclusion of each subject short methods of solution are outlined. Definitions of all the principal terms are suggested, and there are rules that every pupil should memorize after he has mastered the principles or processes which they describe. H. E. C.

Household Arithmetic, by Katherine F. Ball, M. A., Vocational Adviser for Women, the University of Minnesota, and Miriam E. West, M. A., Teacher of Mathematics, Girls Vocational High School, Minneapolis. Pages 271. 14×20 cm. 1920. J. B. Lippincott Company, Philadelphia.

If it is true that girls need more training in the kind of mathematics used in everyday life than is afforded in the traditional course, this *Household Arithmetic* is most admirably worked out to remedy the defect. The authors have used the subject matter of home economics for this text, which aims to enable girls to understand and to interpret the economic problems in their own homes; to develop skill in the computations and the methods of reasoning involved in everyday affairs so that arithmetic may become a tool in effective living; and to make girls readily see controlling number relations in practical situations.

The problems are arranged under the topics, budgets and accounts, shelter, operation, clothing, food, and higher life. There are thirty-nine illustrations, a three page bibliography, and a very complete index. Teachers interested in vocational arithmetic should surely examine this book. H. E. C.

Applied Arithmetic, by N. J. Lennes, Professor of Mathematics in the University of Montana, and Frdnces Jenkins, Professor of Elementary Education in the University of Cincinnati. Book 2. Pages ix+294. Book 3. Pages ix+340. 13×19 cm. 1920. J. B. Lippincott Company, Philadelphia.

The first mentioned book covers the work in arithmetic in the fifth and sixth grades, while the second book covers the work in the seventh and eighth grades. It has been the purpose of the authors to find the

Digitized by Google

We Cover the Earth

Here is the list of countries to which SCHOOL SCIENCE AND MATHEMATICS goes each month:

Every State in the United States, every Province in Canada, Mexico, Cuba, Porto Rico, Brazil, Argentine, Chile, Peru, Ecuador; nearly every country in Europe (before the war every country); Egypt, Liberia, Cape Colony, The Transvaal, Persia, Ceylon, India, China, Korea, Japan, Philippines, New Zealand, Australia and Hawaii.

The only Journal in the English language devoted primarily to the needs of Science and Mathematics teachers in High Schools.

Remember this when deciding upon your subscription list of periodicals for Science and Mathematics.

This Journal is the only Journal whose pages are devoted to all phases of progressive Secondary Science and Mathematics Teaching.

Be a partner in this enterprise by investing $2.50 with it each year. Those teaching these subjects in Secondary Schools who wish to be progressive should be subscribers to this Journal.

During the last ten years it has accomplished more in placing Science and Mathematics teaching on its present high plane than any other agency.

Wide awake Mathematics teachers should have it to keep abreast of the times. Progressive Science teachers should read it to keep themselves alive in their subjects.

The best instructors in any subject are those broad enough in their pedagogical views to have a knowledge of what those in other subjects are doing.

SCHOOL SCIENCE AND MATHEMATICS is the only Journal through which you can receive this knowledge.

School Science and Mathematics

2059 East 72nd Place

CHICAGO. ILL.

Digitized by Google

basis for arithmetic in the simple, obvious facts of the stream of life that flows about the child. Systematic use has been made of games of group competition. Many suggestions for bringing in local material are made throughout the books. The large number of illustrations and diagrams make the books very attractive. Teachers should examine this series of arithmetics. H. E. C.

Plane Trigonometry for Secondary Schools, by Charles Davison, Sc. D., Mathematical Master at King Edward's High School, Birmingham. Pages 334. 13×19 cm. 1919. Cambridge University Press.

The first part of this book includes the ordinary course of elementary trigonometry, though graphs and the solution of equations are treated rather more fully than usual. The second part, Chapters XVII-XX, deals with inequalities, approximations and errors, de Moivre's theorem, and series. There is an abundance of problems, including many excellent applications. This is a good reference book for the teacher in this country since it contains many types of problems not found in our textbooks. H. E. C.

Applied Mathematics, by Eugene H. Barker, formerly Head of the Department of Mathematics in the Polytechnic High School, Los Angeles, Calif. Pages viii+247. 13×19 cm. 1920. Allyn and Bacon, New York.

This book furnishes in teachable form an adequate treatment of the fundamental operations of arithmetic, a consideration of ordinary business transactions, practice in the use of letters and simple algebraic operations in handling formulas, mensuration problems, and a study of graphic charts. The examples and problems have been selected from many fields, industrial, commercial, mechanical, agricultural, and as far as possible are such as occur in the household, on the farm, in the factory, and at the office. Those who are interested in practical courses in arithmetic will do well to examine this book. H. E. C.

Infinitesimal Calculus, Re-issue, by F. S. Carey, M. A., Professor in the University of Liverpool. Pages x+352. 14×22 cm. $4.25. 1919. Longmans, Green and Co., New York.

This book is not written for any particular group of students; it is designed for those who wish to use calculus as an instrument in the attainment of further knowledge. It is therefore essentially a book of practical mathematics. The fundamental ideas are explained at great length, and the student is advised to return again and again to the earlier chapters. If this were generally practiced there would be fewer failures in this subject. The exercises are numerous and cover many fields. Students in calculus using this as a reference book will find much help in understanding the principles of the subject and in applying them in the solution of problems. H. E. C.

Elements of Vector Algebra, by L. Silberstein, Ph.D., Lecturer in Natural Philosophy at the University of Rome. Pages 42. 14×22 cm. $1.60. 1919. Longmans, Green and Co., New York.

The author states that while this book is scarcely more than a synoptical presentation of the elements of vector algebra covering the needs of those engaged in geometrical optics, it is hoped that it will serve the more general purpose of providing everybody unacquainted with the subject with an easy introduction to the use of vector algebra. In such a brief and condensed discussion of the subject the author has succeeded in giving the reader a clear and rather easily grasped understanding of the use of vector algebra. H. E. C.

Digitized by Google

School Science and Mathematics

Member of the Educational Press Association of America

No Numbers Published for JULY, AUGUST and SEPTEMBER.

PRICE. The subscription price is Two Dollars and Fifty Cents a year, if paid in advance; single copies 30 cents.

ALL REMITTANCES should be made payable to the order of **School Science and Mathematics. Remittances should be made by Post Office Money Order, Express Order, or Bank Draft.** If personal checks are sent, please add ten cents for collection.

SCHOOL SCIENCE AND MATHEMATICS is the "official organ" of the following associations: The Central Association of Science and Mathematics Teachers, Eastern Association of Physics Teachers, The Physics Club of New York, Missouri Society of Teachers of Mathematics and Science, Science and Mathematics Section of the Oregon State Teachers Association, Saskatchewan Science and Mathematics Teachers Association, Southern Parific Science and Mathematics Teachers Association, Kansas Association of Mathematics Teachers New York State Science Teachers Association, New Jersey Science Teachers Association.

POSTAGE IS PREPAID for all subscriptions in the United States and Mexico. For Canada add 25 cents for postage. For all other countries in the Postal Union, add 50 cents.

CHANGE OF ADDRESS. Subscribers should send notice of any change of address before the 12th of each month; otherwise they are held responsible for magazine, sent to their former address, and no duplicate copies will be sent except on payment of 30 cents for each copy. Send notices to School Science and Mathematics, Mount Morris, Ill., or 2059 East 72nd Place, Chicago.

MANUSCRIPTS. Contributions on Science and Mathematics Teaching are invited. Articles must be written on one side of the sheet only. All illustrations must be drawn or written in jet black on a separate sheet of manuscript. Contributors are requested to write scientific and proper names with particular care. Manuscripts should be sent to the Editor of **School Science and Mathematics, 5517 Cornell Ave., Chicago,** or to the proper departmental Editor. Books and pamphlets for review should be sent to the Editor. To insure insertion in any number, manuscript must be in the editor's *possession not later than the 20th of the second month before* publication.

MISSING NUMBERS will be replaced *free* only when claim is made within thirty days after receipt of the number following.

REPRINTS, if desired, must be ordered in advance of publication. Reprints of leading articles will be printed as ordered, the actual cost (with cover, if desired) to be paid for by the author. Reprints *must* be *paid* for when ordered. The table below shows the *approximate* cost of reprints consisting of plain text or text with line engravings. The actual cost may vary from the figures given and will depend upon the amount of work in re-making the pages into forms, press work, paper, printing, etc.

Number of Copies	100	Extra Hundreds	Number of Copies	100	Extra Hundreds
2 pages	$1.50	$0.25	16 pages	$6.65	$1.35
4 pages	2.10	.45	20 pages	8.70	1.55
8 pages	4.30	.80	Cover, extra	2.75	.45
12 pages	6.00	1.20			

SCHOOL SCIENCE AND MATHEMATICS

PUBLICATION OFFICE **MOUNT MORRIS, ILLINOIS**

Business Office, 2059 72nd Place, Chicago.

Editorial Office, 5517 Cornell Ave., Chicago.

Digitized by Google

DIRECTORY OF SCIENCE AND MATHEMATICS SOCIETIES.

Under this heading are published in the March, June, and October issues of this Journal the names and officers of such societies as furnish us this information. We ask members to keep us informed as to any change in the officiary of their society. This is extremely valuable information to all progressive teachers. Is your Society listed here? Names are dropped when they become one year old.

AMERICAN GEOGRAPHICAL SOCIETY OF NEW YORK.

President, John Greenough; *Vice-Presidents*, Paul Tuckerman and James B. Ford; *Foreign Corresponding Secretary*, William Libbey; *Domestic Corresponding Secretary*, Archibald D. Russell; *Recording Secretary*, Hamilton Fish Kean; *Treasurer*, Henry Parish; *Director and Editor*, Isaiah Bowman, Ph.D.—1220.

AMERICAN PHYSICAL SOCIETY.

President, J. S. Ames, Johns Hopkins University, Baltimore, Md.; *Vice-President*, Theodore Lyman, Harvard University, Cambridge, Mass.; *Secretary*, D. C. Miller, Case School of Applied Science, Cleveland, Ohio; *Treasurer*, G. B. Pegram, Columbia University, New York City; *Editor*, F. Bedell, Cornell University, Ithaca, N. Y.; *Local Secretary for the Pacific Coast*, E. P. Lewis, University of California, Berkeley, Cal. *The Council of the Society consists of the President, Vice-President, Secretary, Treasurer, Managing Editor, all living Past Presidents and eight elected members as follows: Past Presidents:* A. A. Michelson, A. G. Webster, Carl Barus, E. L. Nichols, Henry Crew, W. F. Magie, Ernest Merritt, R. A. Millikan, H. A. Bumstead; *Elected Members:* Max Mason, G. O. Squier, H. A. Wilson, A. L. Day, G. F. Hull, G. K. Burgess, J. C. McLennan, F. B. Jewett; *Editor*, Frederick Bedell, Ithaca, N. Y.—220.

AMERICAN SOCIETY OF NATURALISTS.

President, Dr. Jacques Loeb, Rockefeller Institute for Medical Research, New York City; *Vice-President*, Prof. Bradley M. Davis, University of Michigan, Ann Arbor; *Secretary*, Prof. A. Franklin Shull, University of Michigan, Ann Arbor; *Treasurer*, Dr. J. Arthur Harris, Carnegie Institution for Experimental Evolution, Cold Spring Harbor, Long Island, N. Y.—220.

AMERICAN SOCIETY OF ZOOLOGISTS.

President, Gilman A. Drew, Marine Biological Laboratory, Woods Hole, Mass.; *Vice-President*, Caswell Grave, Washington University, St. Louis, Mo.; *Secretary-Treasurer*, W. C. Allee, Lake Forest College, Lake Forest, Ill.—220.

ASSOCIATION OF AMERICAN GEOGRAPHERS.

President, Charles R. Dryer; *First Vice-President*, Dr. Herbert E. Gregory; *Second Vice-President*, Dr. Isaiah Bowman; *Secretary*, Dr. Oliver L. Fassig; *Treasurer*, Francois E. Matthes.—1219.

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS.

President, Wilmon Newell, Gainesville, Fla.; *First Vice-President*, H. A. Gossard, Wooster, Ohio; *Second Vice-President*, E. M. Ehrhorn, Honolulu, H. T.; *Third Vice-President*, J. G. Sanders, Harrisburg, Pa.; *Fourth Vice-President*, F. B. Paddock, Ames, Iowa; *Secretary*, S. F. Burgess, Melrose Highlands, Mass.; *Editor*, E. Porter Felt, Nassau, Rens. Co., N. Y.—220.

ASSOCIATION OF TEACHERS OF MATHEMATICS IN THE MIDDLE STATES AND MARYLAND.

President, W. E. Breckenridge, Stuyvesant High School, New York City; *Vice-President*, Louisa M. Webster, Hunter College, New York City; *Secretary*, C. B. Walsh, Friends' Central School, Philadelphia, Pa.; *Treasurer*, Clarence P. Scobori, Polytechnic Prep. School, Brooklyn, N. Y.; *The Council*, William Betz, Rochester, N. Y.—220.

CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

(*Annual Meeting*, November 25, 26, 27, *at Englewood High School, Chicago.*)

President, J. A. Foberg, Crane Technical High School, Chicago; *Vice-President*, Frederick R. Gorton, State Normal College, Ypsilanti, Mich; *Treasurer*, Lewis L. Hall, Morgans Park High School, Chicago; *Corresponding Secretary*, Ally L. Marlatt, University of Wisconsin, Madison;

Digitized by Google

LABORATORY APRONS

Send for Descriptive Circular and Prices

CANVAS PRODUCTS CORP.
SCHOOL DEPT.
Fond du Lac, :: Wis.

BIOLOGICAL MATERIAL
FOR
EXHIBITION AND DISSECTION
H. EDWARD HUBERT
Send for new price list Now
3615 MELPOMENE ST. NEW ORLEANS, LA.

This Journal does all kinds of printing. Give us a trial, and we will always hold your trade.

New Words

Every teacher should be up to date and know the *new* words and how to pronounce them.

fourth arm	empennage	convertible
camouflage	backswept	crank case
calibrate	Albatros	landaulet
blighty	squadron	cyclecar

"The Supreme Authority"

WEBSTER'S NEW INTERNATIONAL DICTIONARY

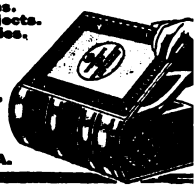
contains answers to questions about these *new* words and hundreds of thousands of other words.

Where else is this information to be found? Ask for the *Merriam* Webster.

400,000 Vocabulary Terms.
30,000 Geographical Subjects.
12,000 Biographical Entries.
6,000 Illustrations and 2,700 Pages.

WRITE for Free Booklets to Teachers: "What Fun to Play Merriam-Dictionary Games," "Unlocks the Door," "Dog-Day Club."

G. & C. MERRIAM CO.
Springfield, Mass., U. S. A.



Laboratory Apparatus and Supplies

We can make immediate delivery on
MICROSCOPES

We prepare
SKELETONS
LANTERN SLIDES
MODELS
MICROSCOPE SLIDES

Laboratory glassware and dissecting instruments for *rush orders*.

We are the Western Branch of the Marine Biological Laboratory of Woods Hole, Mass.

Catalogs are free. Write now.

The General Biological Supply House, Inc.

1177 East 55th St. :: :: :: Chicago, Ill.

Assistant Treasurer, E. S. Tillman, High School, Hammond, Indiana; the *Recording Secretary*, Harry O. Gillet, the University of Chicago, was elected last year for a two-year term. *Section Officers for 1920:*

Biology—Chairman, Grace J. Baird, Bowen High School, Chicago; *V.-Chairman*, C. P. Shideler, Joliet Twp. High School, Joliet, Ill.; *Secretary*, Elizabeth Foss, North High School, Minneapolis, Minn.; *Chemistry—Chairman*, B. J. Rivett, Northwestern High School, Detroit, Mich.; *V.-Chairman*, George Sype, Austin High School, Chicago; *Secretary*, K. J. Stouffer, Wayland Academy, Beaver Dam, Wis.; *General Science—Chairman*, G. A. Bowden, University School, Cincinnati, Ohio; *V.-Chairman*, George Mounce, LaSalle-Peru Twp. High School, LaSalle, Ill.; *Secretary*, Ruth C. Russell, Lake View School High, Chicago; *Geography—Chairman*, Wellington D. Jones, The University of Chicago, Chicago; *V.-Chairman*, R. R. Robinson, Joliet Twp. High School, Joliet, Ill.; *Secretary*, Anne B. Royeston, Hyde Park High School, Chicago; *Home Economics—Chairman*, Harriet Glendon, Lewis Institute, Chicago; *V.-Chairman*, Treva E. Kauffman, Ohio State University, Columbus, Ohio; *Secretary*, Maude M. Firth, Supervisor Home Econ., Davenport, Ia.; *Mathematics—Chairman*, M. J. Newell, High School, Evanston, Ill.; *V.-Chairman*, W. E. Beck, High School, Iowa City, Iowa; *Secretary*, Elsie G. Parker, Oak Park High School, Oak Park, Ill.; *Physics—Chairman*, H. Clyde Kreneriek, North Div. High School, Milwaukee, Wis.; *V.-Chairman*, C. F. Phipps, State Normal School, DeKalb, Ill.; *Secretary*, Glenn W. Warner, Englewood High School, Chicago.—1119.

BOTANICAL SOCIETY OF AMERICA.

President, N. L. Britton, New York Botanical Garden; *Vice-President*, C. E. Allen, University of Wisconsin; *Secretary*, J. R. Schramm, Cornell University, Ithaca, N. Y.; *Treasurer*, Edmund W. Sinnott, Connecticut Agricultural College, Storrs, Conn.—320.

CHEMISTRY TEACHERS' CLUB OF NEW YORK CITY.

President, Alton I. Lockhart, Horace Mann School, New York City; *Vice-President*, J. Ellis Stannard, Boy's High School, Brooklyn, N. Y.; *Secretary*, Floyd L. Darrow, Polytechnic Preparatory Country Day School, Brooklyn, N. Y.; *Treasurer*, J. Hood Branson, Evander Childs High School, Bronx, N. Y.

EASTERN ASSOCIATION OF PHYSICS TEACHERS

President, Charles E. Stratton, Mechanic Arts High School, Boston, Mass.; *Vice-President*, Wallace E. Richmond, Classical High School, Newton, Mass.; *Secretary*, Kurt G. Busick, Technical High School, Newton, Mass.; *Treasurer*, William F. Rice, Public Latin School, Boston Mass.

ECOLOGICAL SOCIETY OF AMERICA.

President, Barrington Moore, American Museum of Natural History, New York City; *Secretary*, Dr. A. O. Weese, University of New Mexico, Albuquerque, N. M.—220

GENERAL SCIENCE CLUB OF NEW ENGLAND.

President, J. Richard Lunt, Poston English High School; *Vice-President*, W. H. D. Meier, Framingham Normal School; *Secretary*, Edith L. Smith, Poston Normal School; *Treasurer*, C. H. Stone, Boston English High School.—320.

INTERNATIONAL METALLURGICAL AND CHEMICAL SOCIETY.

President, Leo A. Carver; *Vice-President*, Dr. Carl Valdemar; *Directors*, B. B. Joseph, Benj. W. Sands; *Directing Secretary and Editor*, Roy Franklin Heath, P. O. Box 270, Billings, Montana.—520.

IOWA ASSOCIATION OF MATHEMATICS TEACHERS.

President, W. J. Rusk, Grinnell College, Grinnell, Iowa; *Vice-President*, O. F. Nixon, Principal of High School, Fairfield, Iowa; *Secretary-Treasurer*, Ira S. Condit, Iowa State Teachers College, Cedar Falls, Iowa.—120.

Digitized by Google

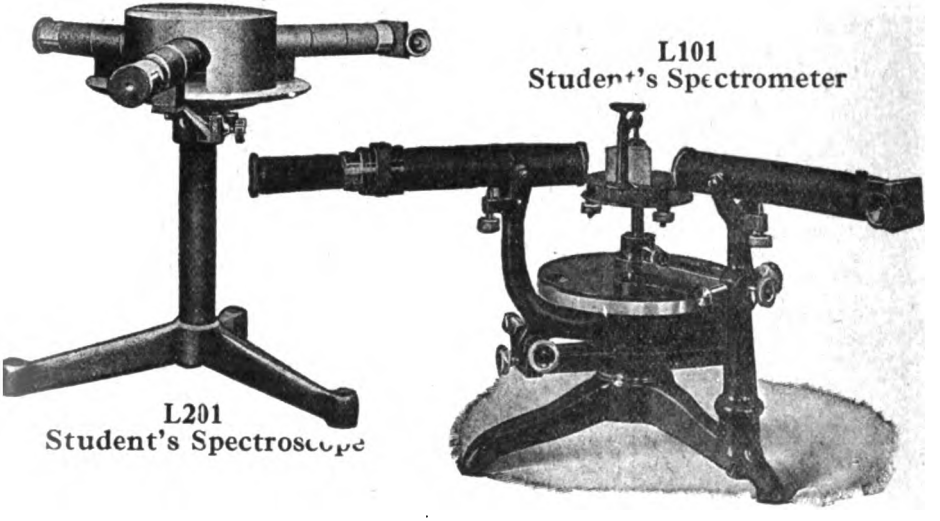
AMERICAN-MADE

Spectroscopes *and* Spectrometers

For Sale by All Dealers

GRATIFYING approval has been accorded by the teaching profession and by industrial laboratories to the Gaertner type of Spectroscopes and Spectrometers, each of which instruments is produced in two most-used models, the one for student, the other for laboratory use.

Our current lot of Spectroscopes of both models is oversold, and an additional quantity of each is in work. So, also, with the Student's Spectrometer, but orders for quick delivery can still be accepted on L105, the Laboratory Spectrometer, while delivery on the other three will not be long delayed.



L101
Student's Spectrometer

L201
Student's Spectroscope

These instruments, in their elegance, simplicity and precision of workmanship, set a distinctly American mode in instrument-making, embodying, as they do, the best in foreign practice, along with the utmost of worth-while individuality that the maker's many years' experience has been able to contribute thereto.

These Spectroscopes and Spectrometers are made also in models of greater precision for special use, and amongst these others we look forward to completing, during 1920, our New Wave Length Spectrometer, advance orders for which will be filled in rotation as received.

For full information we refer to our Catalog "L" of Optical Instruments.

William Gaertner & Co.

5345-5349 Lake Park Avenue, Chicago, U. S. A.

Digitized by Google

IOWA SECTION OF THE MATHEMATICAL ASSOCIATION OF AMERICA.
President, Ira S. Condit, Iowa State Teachers College, Cedar Falls Iowa; *Secretary*, Le Roy Coffin, Coe College, Cedar Rapids, Iowa.—120.

KANSAS ASSOCIATION OF MATHEMATICS TEACHERS.
President, J. A. G. Shirk, Pittsburg, Kansas, one year; *Vice-President*, Emma Hyde, Emporia, Kansas, one year; *Secretary-Treasurer*, Edna E. Austin, No. 6 The Devon, Topeka, Kansas, three years.—1119.

MATHEMATICAL ASSOCIATION OF AMERICA.
President, David Eugene Smith, Teachers College, Columbia University; *Vice-Presidents*, Helen A. Merrill, Wellesley College, Wellesley, Mass., and E. J. Wilczynski, University of Chicago, Chicago, Ill.; *Secretary-Treasurer*, W. D. Cairns, Oberlin College, 27 King Street, Oberlin, Ohio.—120.

MATHEMATICS CLUB OF ST. LOUIS.
President, Alfred Davis, Soldan High School; *Secretary-Treasurer*, Meta Eitzen, Yeatman High School.—620.

MISSOURI SOCIETY OF SCIENCE AND MATHEMATICS TEACHERS.
President, J. L. Laughlin, Kansas City, Mo.; *Secretary*, Alfred Davis, Soldan High School, St. Louis, Mo.; *Treasurer*, A. J. Schwartz, St. Louis, Mo. *Mathematics Section: President*, William A. Luby, Kansas City, Mo.; *Secretary*, Eula Weeks, Cleveland High School, St. Louis, Mo. *Science Section: President*, W. S. Wake, St. Louis, Mo.; *Secretary*, Dora Reynolds, Macon High School, Macon, Mo.—620.

NEW ENGLAND ASSOCIATION OF CHEMISTRY TEACHERS.
President, William W. Obear, High School, Somerville, Mass.; *Curator*, Lyman C. Newell, Boston University, Boston, Mass.; *Secretary*, S. Walter Hoyt, Mechanic Arts High School, Boston, Mass.; *Treasurer*, Alfred M. Butler, High School of Practical Arts, Boston, Mass.—120.

NEW JERSEY SCIENCE TEACHERS' ASSOCIATION.
President, Merton C. Leonard, Dickinson H. S., Jersey City; *Vice-President*, Walter J. Dumm, Barringer H. S., Newark; *Secretary-Treasurer*, Carl J. Hunkins, South Side H. S., Newark; *Recording-Secretary*, Agnes V. Luther, Newark Normal School, Newark; *Chairman Biology Section*, F. H. Hodgson, High School, Montclair; *Secretary Biology Section*, Miss L. H. Seeley, Dickinson H. S., Jersey City; *Chairman Chemistry Section*, C. E Dull, South Side H. S., Newark; *Secretary Chemistry Section*, Miss Pauline McDowell, Battin H. S., Elizabeth; *Chairman Physics Section*, W. H. Platzer, High School, Kearny; *Secretary Physics Section*, Carl O. Voegelin, Central C. & M. T. H. S., Newark; *Chairman Elementary Science Section*, Miss Edith L. Spencer, South Side H. S., Newark; *Secretary Elementary Science Section*, Miss Julia G. Pierce, High School, Paterson; *Members at large of the Executive Committee*, Dr. M. T. Cook, Rutgers College, New Brunswick, and Miss Edith S. Merritt, Dickinson H. S., Jersey City.—120.

SOUTHERN CALIFORNIA SCIENCE AND MATHEMATICS ASSOCIATION.
President, E. E. Chandler, Occidental College; *Vice-President*, Olive Kelso, John Muir Intermediate School, Pasadena; *Secretary-Treasurer*, N. D. Knupp, High School, Santa Monica. *Mathematics Section: Chairman*, J. S. Goldthwaite, Lincoln High School, Los Angeles; *Secretary*, Bertha Sanborn, Polytechnic High School, Los Angeles. *Biology Section: Chairman*, J. D. McDonald, High School, Pasadena; *Secretary*, Minnie Yonge, High School, Long Beach. *Earth Science Section: Chairman*, Agnes C. Ralph, High School, Owensmouth; *Secretary*, Eunice C. Munson, Lincoln High School, Los Angeles. *Physics-Chemistry Section: Chairman*, M. L. Fluckey, Lincoln High School, Los Angeles; *Secretary*, J. C. Owen, High School, Pomona.—520.

Digitized by Google

Vol. XX. No. 8 Whole No. 172

NOVEMBER, 1920

SCHOOL SCIENCE AND MATHEMATICS

A Journal for All Science and Mathematics Teachers

Founded by C. E. Linebarger

SMITH & TURTON, Publishers

Publication Office, Mount Morris, Illinois

CHICAGO OFFICE, 2059 East 72nd Place, CHICAGO, ILL.

CHARLES H. SMITH
EDITOR
le Park High School, Chicago

CHARLES M. TURTON
BUSINESS MANAGER
Bowen High School, Chicag

DEPARTMENTAL EDITORS

culture—Aretas W. Nolan
The University of Illinois, Urbana, Ill.
onomy—George W. Myers
The University of Chicago
ogy, Research in—Homer C. Sampson
The Ohio State University, Columbus
ny—Worralo Whitney
Hyde Park High School, Chicago
nistry—Frank B. Wade
Shortridge High School, Indianapolis, Ind.
nistry, Research in—B. S. Hopkins
The University of Illinois, Urbana, Ill.
l Science—William M. Gregory
Normal Training School, Cleveland, Ohio
General Science—Fredric D. Barber
State Normal University, Normal, Ill.
Mathematics—Herbert E. Cobb
Lewis Institute, Chicago
Mathematics Problems—Joseph A. Nyberg
Hyde Park High School, Chicago
Physics—Willis E. Tower
Englewood High School, Chicago
Physics, Research in—Homer L. Dodge
The State University of Oklahoma, at Norman. Representing American Physical Society
Science Questions—Franklin T. Jones
Warner and Swasey Co., Cleveland, Ohio
Zoology—Harold B. Shinn
Schurz High School, Chicago

ublished Monthly October to June, Inclusive, at Mount Morris, Illinois
Price, $2.50 Per Year; 30 Cents Per Copy

ed as second-class matter March 1, 1913, at the Post Office at Mount Morris, Illinois, under th
of March 3, 1879

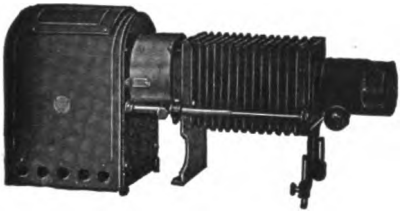
Digitized by Google

"McIntosh Lanterns Are Honest Lanterns."

Lantern Slides of Science

A copy of our Catalogs of science slides was mailed when published to every member of the Central Association. Are you a member? Did you get your copy? Did you keep it?

If not, there is another copy for you if you are interested. Just write us a card and ask for it. No obligation. You'll need it in placing your orders for science slides.



Lanterns from $43.00 up. Opaque and micro projectors, slides and accessories.

McINTOSH STEREOPTICON COMPANY
410 Atlas Block, CHICAGO, ILL.

VIVIAN'S

EVERYDAY CHEMISTRY

"The Chemistry of Life—Not of Books"

New York
Chicago
Cincinnati
Boston
Atlanta

AMERICAN BOOK COMPANY
330 East Twenty-second Street
CHICAGO, ILLINOIS

Please mention School Science and Mathematics when answering Advertisements.

Digitized by Google

SCHOOL SCIENCE AND MATHEMATICS

VOL. XX, No. 8 NOVEMBER, 1920 WHOLE No. 172

RESEARCH IN CHEMISTRY.

Conducted by B. S. Hopkins,
University of Illinois, Urbana.

It will be the object of this department to present each month the very latest results of investigations in the pedagogy of chemistry, to bring to the teacher those new and progressive ideas which will enable him to keep abreast of the times. Suggestions and contributions should be sent to Dr. B. S. Hopkins, University of Illinois, Urbana, Ill.

THE PASSIVE STATE: A REVIEW OF THE THEORIES.

BY J. H. REEDY,
University of Illinois, Urbana, Ill.

The fact that certain metals may become inactive, and behave towards chemical reagents as if they were nobler than would be expected from their place in the E. M. F. series, has been known for more than a century. But simple as this fact is, chemists have never been able to explain it in a manner that is wholly satisfactory, and the phenomenon still remains one of the unsolved problems of the science.

Passivity was discovered in the case of iron, and this metal still remains not only one of the most marked, but one of the most baffling examples of this phenomenon. John Kier in 1790 found that iron which had been dipped in fuming nitric acid had lost its normal chemical behavior, such as the displacement of hydrogen from dilute sulfuric acid, and copper from copper sulfate solution; in fact, it behaved as one of the noble metals. Schoenbein called this state of chemical inactivity "passivity." More recently the phenomenon has been found to exist in other metals, notably chromium and nickel.

The lists of metals assuming the passive form as given by various writers are not identical. All include iron, chromium and nickel—the metals which show the phenomenon in its most

Digitized by Google

marked form. Beyond these three elements, differences appear. Some consider cobalt to show passivity of the normal type, while others deny its genuineness. In addition to the metals just mentioned, those most frequently classed as passive are bismuth, molybdenum and tungsten. Some give larger lists, including elements like copper, lead and silver. In this extended sense, aluminium is said to be passive in nitric acid since there is no appreciable action. Some go even further and speak of pure zinc being passive when it does not dissolve in dilute sulfuric acid. An interesting case of this sort is gold, which has been reported by Coehn and Jacobsen.[1] When gold is made the anode in $AuCl_3$ solution, it dissolves at about the rate that would be expected from Faraday's law until an anode potential of about 1.2 volts[2] is reached. Above 1.4 volts, however, the metal becomes passive, and no action occurs until 1.73 volts is reached, when chlorine ions begin to be discharged.

These differences doubtless arise, not only from differences in the degree of passivity shown by various metals, but from different conceptions as to the nature of the phenomenon in the minds of the various writers. Some (e. g., Heathcote) assume that passivity is wholly electrochemical in nature, and consequently do not include in their lists metals whose passivity is chemical only. Very probably, if all could agree upon a definition of passivity, the conflict in opinions would be largely reduced. It might be said in this connection that most writers now appear to limit passivity to those cases where no visible protecting layer forms on the surface of the metal.

Passivity may be induced in two ways: (1) By the action of oxidizing agents, as HNO_3, H_2CrO_4, H_2O_2, etc.; and (2) by anodic polarization; that is, by making the metal the anode in an electrolytic cell containing alkalies, or solutions containing such anions as NO_3^- and SO_4^-. This inactive condition is not permanent, but disappears slowly on standing, and more rapidly upon subjecting it to heat, mechanical strains, action of non-oxidizing acids like HCl, cathodic polarization, contact with active metals, and so forth.

The Oxide Film Theory.—The earliest theory to explain passivity was the formation of a film of oxide, which acts as a protective layer, preventing further corrosion. This theory is usually accredited to Faraday, although he merely suggested it

[1] Z. anorg. Chem., *55*, 321 (1907).
[2] Referred to the normal hydrogen electrode as 0.0 volts.

Digitized by Google

as a possibility. The evidence in favor of it is forceful, even if not conclusive. It is well known that a layer of Fe_3O_4 passivates iron against rusting. In exactly the same way, a coating of Al_2O_3 may protect aluminium, and $PbSO_4$ protect lead. It seems perfectly reasonable that the mechanism for passivating other metals should be analogous. Another line of evidence that favors the oxide film theory is the fact that metals showing the passive state are not attacked by strong alkalies, presumably due to the formation of a film of oxide on their surface. For example, iron may be used as anodes in the electrolysis of caustic soda solutions.

There are, on the other hand, a number of serious objections to the oxide film theory. (1) In many cases there is no visible film of oxide; furthermore, experiments on the reflecting power of passivated metals[3] show that the film (if any) must be of probably less than molecular dimensions. (2) The known oxides do not meet the requirements of the hypothetical oxide in the way of resistance to chemical action. (3) The destruction of passivity by heat is unexplainable in terms of the oxide film. (4) Passivity is removed by contact with air, an oxidizing agent. (5) The single potential of a passive metal varies, and is not constant as would be the case with a metal-metallic oxide electrode. And (6) Hittorff's "experimentum crucis": Chromium, which dissolves in hydriodic acid with the formation of hydrogen and chromous iodide, becomes passive when it is made the anode in the same solution. It is hardly conceivable that an oxide of chromium could have been formed under such conditions.

For reasons such as the above, the oxide film theory is no longer generally accepted, however sufficient it may be in some specific cases. A few years ago a symposium was held in London under the auspices of the Faraday Society,[4] at which papers were read setting forth the views of various prominent men on this interesting phenomenon. It is quite noteworthy that of the seventeen papers and discussions, only one seemed to favor the oxide film theory. But that does not mean that there is any unanimity among chemists as to the physical basis of passivity. Some of the other theories are outlined below.

Gas Film Theories.—Another explanation of the phenomenon

[3] See Mueller and Konigsberger: Z. Elektroch., 13, 659 (1907).
[4] Trans. Farad. Soc., *9*, 203 (1914).

Digitized by Google

of passivity is the formation of films of oxygen or hydrogen, which envelop the surface of the metal and prevent chemical action.

Fredenhagen[5] and Flade[6] have suggested that the metals that show passivity react slowly with the oxygen formed by the decomposition of certain passivating anions when they are discharged. This insulating film in turn exercises a valve action upon the passage of the electric current, so that no corrosion takes place until a higher voltage is impressed, and then it is usually of a different character from what might be considered the normal action. This hypothesis explains very well why passivity is destroyed by heat, and why optical measurements have been unable to detect any change in the surface of the metal. It is open, on the other hand, to some serious objections, viz.: (1) Many passive metals are readily oxidizable, and a retardation in oxide formation is hardly to be expected; (2) it does not explain how iron is passivated in alkalies; and (3) Grave[7] has shown that iron can be passivated by heating in an atmosphere of nitrogen.

That the gas film causing passivity is hydrogen, and not oxygen, is a very interesting supposition, and one that has been developed in slightly differing forms by several writers. The general idea is that hydrogen is a catalyst for the corrosion of the metal, and lacking it, the metal becomes passive. To quote Schmidt's words[8]: "Just as water or other liquids do not boil, even when their vapor pressure is equal to that of the superincumbent pressure, unless a catalyst such as air is present, so the metals which can be passivated dissolve rapidly only in the presence of a catalyst. The most important of such catalysts is hydrogen."

According to Foerster's hydrogen activation hypothesis,[9] the presence of a layer of hydrogen on metals is the normal condition. In the case of the discharge of oxidizing anions, this hydrogen film is removed by oxidation, so that the corrosion action lags for lack of a catalyst. Sackur's hypothesis[10] differs

[5]Z. phys. Chem., *43*, 1 (1903); ibid., *63*, (1908).
[6]Z. Elektroch., *18*, 335 (1912).
[7]Z. phys. Chem., 77, 513 (1911).
[8]Trans. Farad. Soc., *9*, 265 (1914).
[9]Abhand. der Bunsen. Gesell., No. 2 (1909).
[10]Z. Elektroch. *14*, 612 (1908).

Digitized by Google

from the others mainly on the point of how the hydrogen layer is formed. He represents it as formed by the reversible displacement of H_+-ions of the solution by the metal. That is, for a monovalent metal,

$$2 \text{ metal atoms} + 2H_+ \rightleftarrows 2 \text{ cations} + H_2.$$

This theory gives an ingenous explanation of certain facts. For example, certain metals become active when they are heated in an atmosphere of hydrogen, but passive when heated in nitrogen or a vacuum.

Grave[11] supposes that it is not the hydrogen molecule, but the hydrogen ion that causes activity. These ions are absorbed on the surface of the metal and act as the specific catalyst for the corrosion. Evidently, this gives a good explanation for the passivity of iron in alkaline solutions, by the assumption that these activating H^+-ions are removed by the OH^--ions of the solution, leaving the metal passive.

Some of the objections to the various forms of the gas film theory have been met by supposing that the gas does not exist as such, but in the form of an alloy or solid solution with the metal. For example Grube[12] and Reichinstein[13] have urged that passivity is due to the superficial formation of an oxygen alloy (or an oxide alloy) with the anode metal. Others have suggested a hydrogen alloy hypothesis.

Valency Theories.—It is a frequently recurring idea that valence is a property, not only of compounds, but of the uncombined elements themselves. Allotropism has been explained in this way. Starting with this concept, it is easy to imagine that the differences shown upon a metal passing from the active to the passive state are directly due to a change in valence. Finkelstein has assumed that the several modifications of a metal are present in every sample, their proportions depending on temperature, electrical potential and other factors. The chemical behavior of a metal would be governed by the relative concentrations of these allotropic forms. Such a theory, however, would call for a gradual transition from one form to another, and is unable to explain the abrupt changes reported in several metals. Nor does it throw any light upon the conspicuous part played by anions in inducing and destroying passivity.

[11] Z. phys. Chem., *77*, 513 (1911).
[12] Z. Elektroch. *18*, 189 (1912).
[13] Trans. Farad. Soc., *9*, 228 (1914).

Digitized by Google

The most recent of the valency theories is probably to be found in A. W. Stewart's theory of isobaric iron.[14] He considers active iron as bivalent, calling it ferrosum, and finds it to resemble magnesium in its chemical behavior. Partially passivated iron is trivalent (ferricum), and resembles aluminium. Passive iron he imagines as nonvalent, and calls it ferron, after the analogy of argon. No explanation is given of the specific influence of oxidizing anions in effecting the changes of ferrosum to ferricum, and ferricum to ferron.

Drude's electron theory of metals has been extended by R. S. Dean[15] to explain passivity. According to this hypothesis, passivity is due to the removal of the surface electrons by oxidizing agents or anodic polarization, leaving the surface positively charged to a degree corresponding to the higher valences of the metal in question, and resulting in its ennobling. How the resulting deficiency of electrons on the surface of the metals is maintained is explained by the high permeability of the passive metals for electrons, with the result that the electrons on the surface of the metal escape readily into the electrolyte leaving it with a positive charge. Dean insists on two aspects of the passivity problem that are infrequently mentioned, viz.: (1) Passivity is characteristic of paramagnetic bodies only, and (2) it is harder to induce when the metal is under the influence of a magnetic field.

Anion Discharge Theories.—Chemists do not agree as to the mechanism of the reaction when an anode is corroded. One group likes to think of the metal as ionizing directly, and the anions entering into the reaction in a secondary way only. Another group prefers to think of the anions being discharged directly upon the anode, and the discharged ions, or their fragments, attacking the anode material. This latter view is the basis of what has been called the anionic discharge theory of passivity, and has been proposed in varying forms by several writers. In the event the products of the reaction between the metal and the discharged ion are not removed from the anode surface by solution or diffusion, a layer accumulates forming a barrier between metal and solution, breaking the current. This layer does not need to be of more than molecular thickness to effect passivity; furthermore, this form of passivity might be removed by the presence in the solution of some ion or group

[14]Stewart: "Recent Advances in Physical and Inorganic Chemistry" (1919), p. 246.
[15]Am. J. Sci., 47, 123 (1919).

Digitized by Google

that will combine with this insulating layer. According to the opinion of some when anions like NO_3^- and SO_4^{--} are discharged the ion reacts with water or else decomposes, with the formation of oxygen in either case. This oxygen forms a film on the surface of the metal, and this gap prevents further discharge of anions. Considered in this light, the anion discharge theory resolves itself into the Fredenhagen oxygen film theory. On the other hand, Sackur has called the anionic discharge hypothesis into requisition in his hydrogen film theory by assuming that any ion which, upon discharge, will remove the insulating hydrogen layer will prevent passivity. Such ions as Cl^- accomplish this readily, while others like NO_3^- do not. In order to explain why the latter ion is so uneffective in removing the hydrogen layer (which is a very surprising assumption, to say the least) some form of retarded reaction velocity theory must be invoked. So it often happens that some of the theories advanced to explain passivity are not simple concepts, but rather combinations of several hypotheses.

Reaction Velocity Theory.—It seems that at the present time chemists, for the most part, favor a retarded reaction theory of passivity. That is, some step in the solution of the metal may have its velocity reduced almost to the vanishing point, with the result that the metal remains practically undissolved. However, they differ among themselves as to just which step in the process is the one retarded.

Le Blanc[16] has suggested that certain metals may have a low ionization velocity; or—what amounts to the same thing—the ions may have low speed of hydration. The successive steps in the anodic solution of a metal then are:

(1) $\text{Metal} + \oplus \leftrightharpoons \text{Cation}^+$;

(2) $\text{Cation} + H_2O \rightleftharpoons \text{Cation-hydrate}^+$.

A metal is passive, owing to a retardation of one of these reactions. As a result, the ionization potential is easily exceeded, and at a higher potential discharge of the anions begins with little or no action on the metal. In this way, insoluble products (as oxygen, oxides, etc.) may be formed by the discharged anion, but in this case the formation of the insoluble layer is a result rather than a cause of passivity.

This conception of a retarded reaction appears in a number of the theories mentioned above. It is implied in the hydrogen activation theory of Forester, where the action is supposed to

[16] Loc. cit.

Digitized by Google

be catalyzed by hydrogen, and to lag when it is absent. Similarly in the anionic discharge theories, the oxygen layer is due to a retardation of the oxide formation.

Catalytic Theories.—An extension of the reaction velocity theory is that the anode reaction is retarded from lack of the proper catalyst. The usual assumption is, the pure metal is passive by reason of a slow step in the corrosion process, but this slow step may be accelerated by aid of a specific catalyst. The hydrogen activation theory, as developed by Foerster[17], Schmidt[18] and others is the highest type of this hypothesis. The hydrogen is supposed by Foerster to be molecular, while Schmidt and Grave believe that the activating agent is the hydrogen ion. Like Le Blanc, Foerster thinks that the formation of the oxide film is a result, rather than a cause of passivity. Any process that would remove hydrogen, as polarization in the presence of OH^- or other oxidizing anions, would leave the metal passive.

In concluding, it should be said that probably a final and truly comprehensive explanation of passivity has not yet been brought forward. While the oxide film theory is in general disfavor at this time, still there are certain cases (e. g., lead) where solid protective films are known, and for these the old theory seems sufficient and correct. With most other metals, some other explanation seems necessary. As pointed out above, the reaction velocity concept finds most general acceptance at this time, although it is sometimes berated by its opponents because its advocates cannot agree among themselves as to just where the retardation occurs. Very probably a general theory of the mechanism of passivity will never be realized.

[17] Loc. cit.
[18] Z. phys. Chem. 77, 513 (1911).

NO HIGH PLACES IN FLORIDA.

The highest point in Florida whose altitude has been determined is Iron Mountain, in Polk County, which stands 325 feet above sea level, according to the United States Geological Survey, Department of the Interior. The average elevation of the State as computed by the Geological Survey is about 100 feet.

GUAM.

Guam, our little Pacific Island possession, is a mere speck in the "South Sea," as Balboa called the Pacific Ocean, but it is by no means flat. Jumulong Mangloc, the highest point in the island, stands 1,274 feet above the sea, according to a chart published by the United States Geological Survey, Department of the Interior.

Digitized by Google

RESEARCH IN PHYSICS.

Conducted by Homer L. Dodge,
University of Oklahoma, Representing the American Physical Society.

It is the object of this department to present to teachers of physics the results of recent research. In so far as is possible, the articles and items will be non-technical, and it is hoped that they will furnish material which will be of value in the classroom. Suggestions and contributions should be sent to Homer L. Dodge, Department of Physics, University of Oklahoma, Norman, Oklahoma.

THE PRODUCTION OF DAMPED RADIO-WAVES.

By William Schriever,
University of Oklahoma, Norman, Okla.

This article is the first of a series of articles dealing with the application of the principles of physics to wireless telegraphy and telephony. The study of complicated circuits such as are often used in practice has been purposely omitted, since the theory of operation which applies to them is more easily explained by the consideration of the simplest apparatus. Descriptions of some pieces of apparatus actually used in practice have been added, since it was thought that this would be of interest to the practical experimenter.

Wireless signals are carried through space by "radio waves" which are produced by "oscillating circuits." The simplest circuit in which electrical oscillations may occur consists of a condenser and an inductance coil connected in series. Figure 1 shows such a circuit, C being the condenser and L the inductance coil. Of course, a coil having no resistance cannot be constructed, so any circuit used in practical experiments will also have this characteristic.

A condenser, then, is one of the essential elements of an oscillating circuit. In general, a condenser may be considered to consist of two electrical conductors (sheets of foil, wires, metal plates, etc.) electrically insulated from each other by a dielectric (air, glass, paper, mica, etc.). Thus the aerial or antenna of a wireless station is a condenser, the wires of the antenna being one conductor, the earth the second conductor, and the air the dielectric. The insulators which insulate the antenna from the supports also form a very small, though important, part of the dielectric.

If a condenser of sufficient capacity and an electric light bulb be connected in series between ordinary sixty cycle one hundred and ten volt alternating current mains, as is shown in Figure 2,

Digitized by Google

the lamp will glow, showing that a current is flowing through it. But if one hundred and ten volt direct current is used instead of the alternating current, the lamp does not glow, indicating that no current is flowing. However, if a suitable ammeter be substituted in the latter case, a deflection will be observed on first closing the circuit after which the pointer will return to its original position. This shows that a current flowed for a brief period and then ceased. If the connections at A and B be broken and the free lead from the condenser be touched to the free lead of the ammeter, a deflection of the pointer in the opposite direction will be observed, showing that electrical energy was stored up in the condenser.

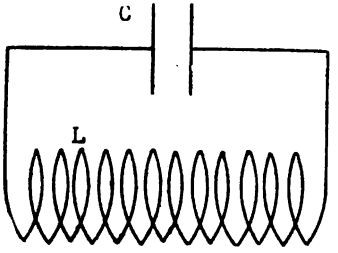


FIGURE 1.

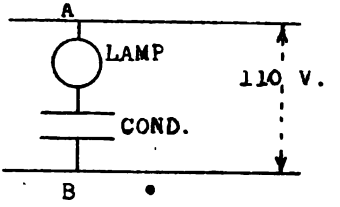


FIGURE 2.

Let us again consider the phenomenon of the glowing electric light bulb mentioned in the preceding paragraph. Suppose that when the circuit is first closed the alternating current main A is at the beginning of a cycle of increasing positive potential. As the potential of A increases for one two-hundred and fortieth of a second a current flows from A through the lamp into the the lower plate of C into the main B. The condenser is now said to be charged. During the next one two-hundred and fortieth of a second the potential of A decreases to zero and during this time a current from the top plate of the condenser flows through the lamp to A and an equal current flows from B into the lower plate. The condenser is now discharged. During the third one two-hundred and fortieth of a second the main B becomes positive and the charge flows into the lower plate of the condenser and, as before, an equal charge flows out of the top plate through the lamp into the main A. And at the end of the fourth one two-hundred and fortieth of a second the condenser is again discharged. Thus, when using sixty cycle alternating current through the circuit in question, the condenser is charged and discharged one hundred and twenty times per second and the pulses of current through the

Digitized by Google

lamp change direction an equal number of times. Since the heating effect of a current is independent of its direction of flow, the heat produced by all the little pulses is the same as that caused by an equivalent unidirectional current. The points to be observed here are, first, that it is possible to store electrical energy in a condenser, and second, that it is possible to transmit electrical energy through a condenser.

Next, let us consider the action of an inductance. If one end of an insulated copper wire, several hundred yards long, be connected to one terminal of a battery of several dry cells and the other end be scratched across the other terminal of the battery, only a very feeble spark will be observed. However, if this same length of wire is wound into a coil on a wooden spool, the sparking is much more vigorous, and if a bundle of soft iron wires is used in place of the wooden spool the sparking effect is increased still more. Evidently the available energy at the breaking of the circuit in the last two cases must be greater than that obtained when a single loop of wire is used. To study this action more in detail, connect a suitable ammeter, A, a coil of insulated wire, L, a double-contact key, K, and a cell, V, in series as is shown in Figure 3. Also connect a resistance R around the cell to the key-contact "Y." When the

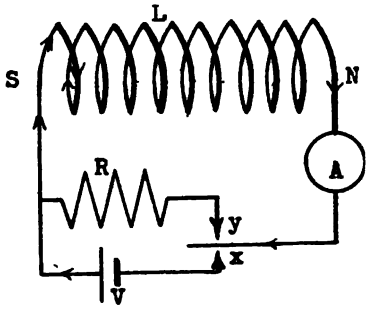


FIGURE 3.

key makes contact at "x," the current flows as is indicated by the arrows and the pointer of the ammeter deflects, say, to the right. If the inductance of L be sufficiently large it will take some little time for the current through it to reach the final steady value, which is indicated by a constant deflection of the ammeter. If the key is suddenly changed from the "x" to the "y" contact, the current, instead of instantly becoming zero, continues to flow in the same direction as it did while the cell

Digitized by Google

was in the circuit, though decreasing rapidly in strength until a value zero is reached. It is evident, from the continued deflection of the ammeter after the cell is cut out of the circuit, that energy is somehow stored up in the circuit. The sparking at the break of a circuit containing a coil, as mentioned above, shows that this energy is stored in some manner by the coil.

The slow building up of the current in the circuit and the continuance of the flow mentioned in connection with Figure 3 may be explained in the following manner. When the current flows through the coil a magnetic field is produced in and around it and the coil has the properties of a magnet (poles marked in Figure 3). Such a magnetic field cannot be built up instantaneously. During the time that it is being built up, the number of "magnetic lines of force" associated with the coil is changing. It will be remembered that, when the number of lines of force through a coil is changing, an electromotive force is induced in the coil, and that this electromotive force is in such a direction that the magnetic field of the resulting current opposes the inducing field (Lenz's Law). Therefore, while the magnetic field is building up the "back" or "counter" electromotive force induced in the coil opposes the electromotive force of the cell; this keeps the current from attaining its full strength at once. When the cell in Figure 3 is suddenly replaced by the resistance, the magnetic field associated with the inductance coil and the current through it have nothing to maintain them, so they tend to reduce to zero. But any reduction in the strength of the magnetic field means a reduction in the number of lines of force associated with the coil. The coil, then, is again cutting lines of force and this cutting is in the opposite direction to that which took place when the field was building up. The induced electromotive force is therefore such as to cause a current to flow in the same direction as the original current. The points to be observed in regard to the action of an inductance coil are, first, that energy can be stored in a magnetic field, and second, that such a coil tends to prevent the current through it from changing in amount.

The operation of the oscillating circuit of Figure 1 depends on the energy-storing properties of the condenser and inductance coil. First assume the coil to have no resistance and the condenser C to be charged and then connect the inductance coil L to it as shown. The condenser immediately starts to discharge through the coil and, in so doing, builds up a magnetic

Digitized by Google

field associated with the coil. When the condenser is completely discharged all of its electrical energy has been used in building up the magnetic field of the coil. As was explained before, the field breaks down and consequently induces a current flowing in the same direction as the one which originally produced the field. The amount of electrical energy produced is just the same as the amount which originally caused the magnetic field, namely, the amount of energy which was in the condenser (since we assumed no energy losses such as would occur in a circuit having resistance). Therefore, the condenser is now charged so that it has the same energy that it had originally, the only difference being that it is charged in the opposite direction. Thus the circuit again contains a charged condenser in series with an inductance coil. The condenser discharges through the coil as before, builds up a magnetic field which again breaks down and charges the condenser so that it is in the same condition that it was originally. Two such surges of current taking place in opposite directions, immediately following one another, constitute one complete electrical oscillation. In the ideal circuit the surges of current back and forth would go on forever, much the same as a weight oscillating up and down on the end of a coil-spring would continue to oscillate forever if there were no friction of any kind.

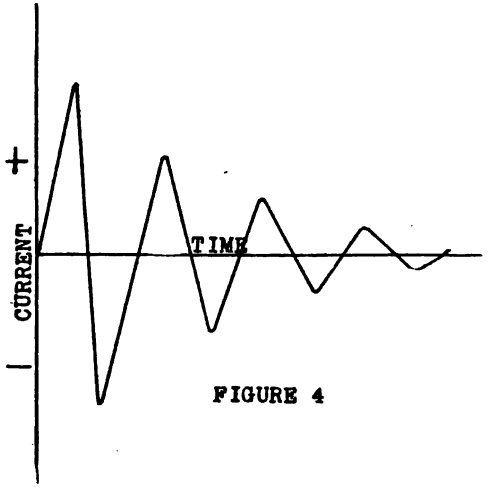


FIGURE 4

In practice, of course, there are heat losses in the wire of the inductance coil. Therefore the maximum current flowing during a given cycle is less than the maximum flowing during the preceding cycle as is shown in Figure 4. In this diagram the

Digitized by Google

instantaneous values of the current are plotted as ordinates with the corresponding times as abscissas. Each loop, either above or below the time axis, represents a half-cycle and it is to be observed that the height of a loop (maximum value of current) decreases with time. This decrease in current goes on until finally all the original energy of the condenser is dissipated as heat; then the oscillations cease. Oscillations which decrease in strength as time goes on are said to be "damped" and the whole group of oscillations shown in Figure 4 is called a "train of damped oscillations." The frequency of the oscillations depends only on the capacity of the condenser and on the inductance of the coil when the resistance of the circuit is small. If L is the inductance in henrys, C the capacity in farads, then the frequency in cycles per second is $f = 1/2\pi\sqrt{LC}$. The frequencies used in "radio" usually range between 100,000 and 1,000,000 cycles per second. The time required for a whole train of damped oscillations is of the order of one one-thousandth of a second, and the number of complete oscillations in a single train is therefore from 100 to 1,000.

Each complete train of oscillations produces a single pulse of current through the phones of the receiving set (this will be explained in a later paper). Consequently the pitch of the note heard in the phones will be the frequency at which the trains of oscillations are produced. If this frequency is that for which the human ear is most sensitive, less energy is necessary at this frequency than at other frequencies when the same audibility of signals is produced. The human ear is very sensitive to sounds whose pitch is about 1,000 cycles per second. Hence this is the rate at which trains of oscillations should be produced in order that the maximum range of transmission for a given circuit may be obtained. In order to accomplish this it is necessary to give the condenser 1,000 initial charges per second, and to allow oscillations to occur for each of these charges. One of the simplest circuits for producing 1,000 trains of oscillations per second is shown schematically in Figure 5. G is an alternating current generator whose frequency is 500 cycles per second. The current from this generator flows through the primary of the "step-up" iron-core transformer when the key is closed. The secondary or "high-side" of the transformer is connected to the terminals of the condenser, C, which is in series with an inductance coil, L, and a spark-gap. C, L and the spark-gap form the circuit in which the oscillations are to take place.

Digitized by Google

When a 500 cycle generator furnishes the power, 1,000 trains of oscillations will be produced each second in the oscillating circuit, as may be seen from the following considerations. The current through the primary attains a maximum value, either positive or negative, once during each half-cycle or 1,000 time per second. For each maximum value of the current in the primary a maximum electromotive force is induced in the secondary of the transformer and this electromotive force is

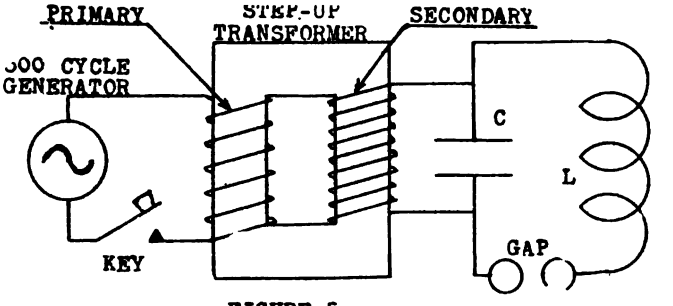


FIGURE 5

applied to the condenser which, therefore, becomes charged. At the time that this induced electromotive force is a maximum, the spark-gap "breaks down" (spark passes across the gap). Due to the great ionization of the air in the gap it becomes a relatively good conductor while the spark is passing. Therefore the condenser, which was charged before the gap broke down, discharges and recharges through the gap and the coil thus producing a complete train of oscillations in the oscillating circuit. For each spark, then, a whole train of oscillations is produced. Since a spark occurs at each maximum induced electromotive force in the secondary, 1,000 sparks will pass and, therefore 1,000 trains of oscillations will be formed per second.

The spark-gap is necessary. If there were no gap, and instead the circuit were completed by some electrical conductor, the current in the secondary of the transformer would pass around through the coil. Under these conditions the condenser would not be charged and oscillations would not occur. The spark-gap acts as a sort of automatic switch which opens so that the condenser will be charged and closes (spark passes) so that the circuit may oscillate. The condenser does not discharge through the secondary of the transformer since the effective resistance of the secondary is large compared to that of the gap and coil in the oscillating circuit.

As long as the key in the primary circuit is closed, sparks

Digitized by Google

and therefore trains of oscillations will be formed at the rate of 1,000 per second. A radio operator, when sending at the rate of about twenty words per minute, holds the key down one

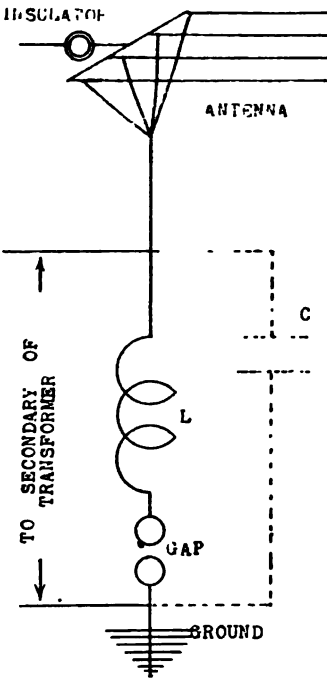


FIGURE 6

twenty-fifth of a second when he makes a "dot" and three twenty-fifths of a second when he sends out a "dash." The dot, therefore, is represented by forty trains of oscillations and the dash by one hundred twenty trains.

We have now arrived at a method for the production of damped electrical oscillations but the possibility of radiating any of the energy in the form of waves in the ether, namely radio waves, has not been considered. An ordinary experimental circuit set up in the laboratory radiates only a small amount of the energy in this way; the remainder is dissipated as heat. An oscillator which radiates a relatively large fraction of the energy is said to have a high radiation resistance. The usual method for increasing the amount of energy radiated by an oscillator is to use an aerial and the ground as condenser plates and the air as the dielectric as is shown in Figure 6. The dotted line condenser and wires simply show how the antenna and ground act as a condenser in series with the inductance coil, L, and the spark-gap.

Digitized by Google

The energy of a charged condenser is stored by what may be termed an electric strain in the dielectric between the plates. This strain is in the ether which permeates all space. In the case of the condenser formed by the antenna and the ground, Figure 6, the strain occurs in the dielectric, i. e., in the ether permeating the air, between the antenna and the ground. This strain is propagated through the ether in all directions from the antenna with the speed of light (186,000 miles per second). If the antenna is first at a positive and then at a negative potential, with respect to the earth, as it is in succeeding half-cycles in a train of oscillations, the ether is strained first in one direction and then in the other, all strains traveling out from the antenna with the same speed. If under these conditions the strains, due to the antenna's becoming positive (or negative), occur at the rate of a million per second, then similar positive strains will follow each other about 328 yards apart. This ether wave is said to have a wave-length of 328 yards or 300 meters. Thus each train of oscillations gives rise to a train of ether waves traveling out from the antenna into space in all directions. An antenna usually radiates more energy in some one direction than in any other direction; it is said to have a directional effect. Thus the inverted L antenna shown in Figure 6 radiates more energy toward the left in the figure than in any other direction.

A train of ether waves produced by a train of electrical oscillations may be likened to a train of sound waves emitted by a tuning-fork which has been struck with a rubber hammer. The sound waves coming from the fork are damped since their intensity decreases with time just as the intensity of the electrical oscillations, and therefore of the ether-waves, decreases with time. The pitch of the sound waves of a train of waves depends on the dimensions of the fork and on the material of which it is made; the frequency of the electrical oscillations is determined by the inductance and capacity of the oscillating circuit. The number of trains of sound waves produced per second will be the same as the frequency with which the fork is struck; in the case of the electrical oscillator the frequency of the trains is the same as the number of sparks per second. The length of the sound-wave in air depends on the pitch of the fork; the length of the electromagnetic wave in the ether is determined by the frequency of the oscillating circuit. In each case the wave-length is $l = V/f$, where V is the velocity of

Digitized by Google

propagation of a wave in the medium (air or ether) and f is the frequency of the oscillator (tuning-fork or oscillating circuit).

Amateurs usually do not have 500 cycle alternating current available but obtain the power for their transformers from the ordinary sixty cycle 110 volt alternating current house lighting mains. Since there is only one spark per half cycle, an oscillator furnished with power from a transformer supplied with this current will produce 120 trains of waves per second. This gives a very low pitch note (second B below middle-C on a piano) compared to a pitch of 1,000 cycles (second B above middle-C) for which the ear is very sensitive. In order to generate more sparks per second a rotary spark-gap is employed in place of the plain gap already mentioned. A rotary gap usually consists of a wheel mounted in front of two stationary knobs or points. The wheel has about ten projecting knobs or points, on the rim. which are so spaced that, as the wheel rotates, knobs on opposite sides of it are simultaneously in front of the stationary knobs The wheel is driven at the desired speed by means of a motor on the shaft of which it is mounted. In this case the spark has to pass across two short gaps, one from each stationary knob to the wheel. These gaps must be short since it is desired to have them break down when the electromotive force induced in the secondary is not at its maximum value. In fact it is possible to have eight sparks for each half-cycle of the primary current; in this case the number of sparks and therefore the note heard by the receiver will have a frequency of 960 cycles per second. The induced electromotive force varies during each half-cycle and consequently the tone heard at the receiver is not musical but it is of high pitch; it therefore has greater audibility than the 120 cycle-note.

An induction coil equipped with a vibrator is a convenient source of high voltage for an oscillator if the amount of power desired is not large (less than one-fourth kilowatt). If the spark-gap is not too small, a spark will occur only at the break of the vibrator. Hence the frequency of the sparks will be the same as the frequency of the vibrator and this is usually less than 100 vibrations per second. Induction coils are rarely used in commercial radio sets but are very often employed by amateurs.

The plain spark-gap first described cannot be used in an oscillator of large power output for it becomes heated and serious arcing takes place. Moreover a spark once started lasts so long that this gap cannot be used with a 500 cycle generator set;

Digitized by Google

the spark is said to be not sufficiently quenched. The rotary gap overcomes this difficulty and it also remains cool and does not arc seriously. It is, however, very noisy and therefore disagreeable to use. The quenched gap overcomes all of these difficulties. The standard form of quenched gap consists of a number of flat, copper or silver discs of large surface, say about three inches in diameter at the sparking surface, with their faces separated by about 0.08 inch (thickness of three sheets of writing paper). To provide the necessary total length of gap for use with high voltages, a number of these short gaps are put in series so that the spark must jump them all. The disks are kept apart by rings of mica or of paper. This form of gap has had such a large surface for heat radiation that it keeps cool and thus does not arc. The ionized gas in the spark is quickly cooled by the large disks and the spark is quenched almost immediately after the gap has broken down; this allows the much-desired high-frequency generator to be used as the source of power.

The inverted-L antenna shown in figure 6 is a very common type of aerial. When the connection to it is made midway between the insulators instead of at one end this type is called a "T" antenna; it is also in common use. Both types are used on ships as well as on land. At some radio stations two inverted-L antennas are supported on three masts in such a way that the two sets of horizontal wires form a "V"; the connection is made at the ends supported by the same mast. Such an aerial is known as a "V" antenna. A vertical wire is the best radiator of electromagnetic energy but it is hardly possible to get one sufficiently long so that it can be used for long wave-lengths. An approximation to an antenna of this type is used on airplanes where a wire about 300 feet in length is trailed behind. The stay-wires and all metal parts of the airplane are electrically connected and take the place of the earth; they are called the counterpoise. A trailing-wire antenna has a very decided directional effect, most of the energy being radiated in the direction in which the airplane is flying. The umbrella type of antenna consists of a number of wires fastened at one end to the top of a tall mast by means of insulators and at the other end to insulators which are attached to anchors; these wires also serve as the guy-wires for the mast and so extend in all directions from the mast as center. The electrical connection is made at the top ends of the insulated sections of the guy-wires. This sort of an antenna radiates energy equally in all directions; it is used at many of the powerful radio stations.

Digitized by Google

INTRODUCTORY COURSES IN BOTANY. V.

By Bradley M. Davis,
University of Michigan, Ann Arbor, Mich.

(Continued from April, 1920.)

Outline No. 17.

A year's high school course, five to seven hours a week.

First half-year.

1. Study of a complete seed plant, including flower and fruit, for a comprehension of the plant as a unit composed of cooperating parts.
2. Leaf structure and leaf types. Uses of leaves determined by experiment. Edible leaves.
3. Flowers. Study of types from simple to complex. Pollination and fertilization.
4. Study of several autumn blooming plants for family characteristics.
5. Structure of monocotyl and dicotyl stems. Distribution of foods manufactured in the leaves. Economic uses of stems.
6. Roots. Garden plants to illustrate root form and food storage.
7. Fruits. Collection from the field and market to illustrate types of fruits and methods of seed dispersal.
8. Weeds. Kinds that seed in the autumn.
9. Bulbs and bulb planting.
10. Trees and forestry.
11. Pines. Acquaintance with several genera of conifers.

Second half-year.

12. Brief study of pteridophytes.
13. Brief study of bryophytes.
14. Brief study of thallophytes.
15. Bacteria.
16. Plant diseases.
17. Seeds and seedlings. Selection and improvement of soils.
18. Spring wild flowers. Representatives of families.
19. Study of native and cultivated shrubs to recognize kinds.
20. Practical garden work. Recognition of weeds

The purpose of the course is to develop a wide-awake interest in growing plants and a general understanding of their vital and economic values. As much work should be carried on out of doors as weather and time will permit.

Outline No. 18.

A year's high school course, five times a week.

1. General study of some familiar plant to understand its parts and their functions. This introductory study is accompanied by field trips on which common plants are noted and various material collected for winter study.
2. Bacteria. Structure, physiology, and relation to disease.
3. Yeast, Structure and relation to fermentation.
4. Algae. Structure of Pleurococcus and Spirogyra. Food manufacture. Development of multicellular plants. Sex.
5. Fungi. Structure and life habits of bread mold. Life history of wheat rust. Mushroom. Saprophytism, parasitism. Economic importance.
6. Lichens. Structure. Symbiosis. Field trip.
7. Bryophytes. General structure of Marchantia. Structure and life history of a moss. Alternation of generations.
8. Fern. Life history with a study of the vegetative structure of the sporophyte. A comparison with the life history of the moss.
9. Pine. Study of vegetative structure and cones. Development of the gametophytes and seed. Field trips to distinguish different kind of conifers. Economic importance.
10. Angiosperms. A comparison with gymnosperms based on studies of the bean and corn. Then follows (11 to 15) a somewhat detailed study of angiosperm structure.

Digitized by Google

11. Roots. Forms and cell structure. Relation to the soil. Functions. Food storage and economic value. Experiments on osmosis and conditions necessary for growth.
12. Stems. Kinds and modification of forms. Cell structure and methods of growth in monocots and dicots. An examination of woods, their economic importance. Grafting and budding.
13. Leaves. Various leaf forms. Cell structure in relation to physiology. Food manufacture, transpiration, respiration. A study of raw materials, conditions and products of photosynthesis. Tests for food products. Food storage and economic importance. Experiments and field trips.
14. Flowers. Several types studied for structure and functions of parts. Pollination.
15. Fruits and seeds. Types and structural adaptations. Dissemination. Foods, determined by tests. Germination of seeds with a study of necessary conditions.
16. Useful plants and their products. Cereals, sugar, oils, fibers, drugs, etc.
17. Weeds. Common forms. Dissemination. Damage. Control.
18. Forestry. Methods and importance of timber conservation.
19. Plant breeding. General principles and methods. Seed selection.
20. Plant diseases. Disease producing fungi. Important diseases and their treatment.

The course traces the development of plants from the simplest to the most complex, but the types are largely chosen with reference to topics, which are assembled about them. In the studies on stems, roots, leaves, etc., where physiology is introduced the teacher performs the experiments for the class. The field trips are regarded as valuable since the pupils thus see plants in their natural environment and collect their own material. Many of the topics studied are important in that they connect the scientific with the practical.

Outline No. 19.

A year's college course, six hours a week.

1. Protoplasm and the organization of the cell. Physical structure and properties of living protoplasm as seen in such plants as Vallisneria, Elodea, stamen hairs of Tradescantia, Characeae, molds, etc. *Demonstrations*: Structural elements in stained cells of young and old tissues.
2. Algae. Border-line organisms (living). Unicellular and multicellular algae; structural characters and life histories of one or more types. Fertilization phenomena as in Fucus, which can be handled by the students themselves. *Optional studies*: Collections of algae common in aquaria, reservoirs, ponds, etc., and their classification in an elementary way. *Experiments;* Gas release in algae of the filamentous type. Tests for starch. Parallel studies on photosynthesis using larger aquatics and land plants. Respiration.
3. Fungi. (1) Molds. Water mold, fruit and bread molds; structure, nutrition, zygospore development demonstrated by cultural methods. (2) Yeast. Culture and morphological study, fermentation experiments. (3) Bacteria. Studies in hanging drop of non-pathogems, simple experiments in cultures and soil suspensions. (4) Fungi of the ascus type, rust, mushroom; general studies and demonstrations. General consideration of parasitism, saprophytism, symbiosis.
4. Liverwort and moss. Morphological features, life histories, nutrition. Sphagnum, its morphology, distribution, economic importance.
5. Fern. Life history. Display of fern allies and fossil forms.
6. Flower. Morphology. Pollination, fertilization, reduction divisions. Development of embryo. *Demonstrations;* Various types of flowers, reproductive structures in the gymnosperms, ovule development and fruit formation, germination of pollen. *Optional;* Observation of plant breeder's methods and general consideration of the principles of genetics.

Digitized by Google

7. Seeds. External and internal morphology of endospermic and non-endospermic types. Tests for storage products: starch, fat, oil, protein. Germination studies, interpretation of parts of seedling in terms of embryo. Tests for digestive products in germinating seeds and seedlings. Extraction of enzymes from leaves and seeds (barley). *Demonstrations;* Fruits and seeds, interpretation of parts, adaptations for dissemination. *Optional;* Garden plot, seed selection, testing, disinfection, planting. Soil studies.

8. Structure of young plant (anatomy and histology). Dissection of macerated tissues to determine various structural units. Freehand sections from seedlings of monocots and dicots of roots, stems and leaves, the interpretation of their tissues and functions. *Experiments;* Diffusion, osmosis, plasmolysis, transpiration, absorption. *Demonstrations;* Wood sections showing differentiation of tissues in their mature form. Forest products. Textile fibers. Comparison of normal and diseased tissues of plants of local and regional importance. *Optional;* A study of the trees with keys adapted to the region. Tree planting, grafting. Ecological studies, represented by cross sections of a woodland area, open country, shore line, pond, lake, etc. Contact with the literature on the subject of forestry and problems related to it obtainable from state and federal bureaus.

9. Bud and twig studies. Content of the winter bud. Tests for storage areas. Observations on the unfolding of buds, growth of twigs, and the addition of new leaves and buds.

10. Key studies. Emphasis on the dominant plant families of the region. General principles of classification. Principles of evolution. Plant distribution. *Demonstrations;* Representatives of the great groups of plants with emphasis on those of economic importance.

The course is designed to give training in the fundamentals of structure essential to the interpretation of function in the living plant. The studies are assembled about the great groups to facilitate the orientation of the student in the plant world and to those portions of it that relate themselves conspicuously to human activities.

Outline No. 20.

A half year's college course required in a premedical curriculum, one lecture, two quizzes, and six hours laboratory work each week.

The lectures mostly treat of principles of plant biology with the subject of organic evolution an outstanding feature. Morphology, life histories, physiology and a simple classification are developed chiefly in the quiz periods, the discussions being based on the laboratory work and text book study. Physiological experiments are introduced as demonstrations.

1. Plant cell. Elodea, for structure and protoplasmic movement plasmolysis, osmosis. Euglena or Chlamydomonas for motile protoplasts.

2. The leaf. A short demonstration and discussion of leaf form. Sections of geranium leaf for chlorenchyma, epidermis and hairs. Epidermis of Boston fern (stripped) for stomata. Stained sections of Andromeda leaf for details of cell organization (slides).

3. Chloroplasts and formation of starch. Fresh sections of stem of Pellionia, later stained with iodine.

4. The stem. Brief discussion and demonstration of stem morphologyr Transverse and lengthwise sections of corn stem (slides). Cross section. of Ricinus stem, two stages covering formation of cambium cylindes. Cross sections of one and two year old stems of Aristolochia, and four year old stem of linden (slides). Study of quartered oak blocks with brief examination of slides.

5. The root. Seedlings of radish for general morphology of young plant and for root regions and root hairs. Root tip of onion (slides). Cross sections of corn root (slides).

6. Mitosis and cell division in root tip of onion.

Digitized by Google

7. Foods and food storage. Potato starch. Whole wheat flour (starch and protein). Starch from endosperm of corn seedling in process of conversion, compared with starch in ungerminated kernel. Sections of Ricinus endosperm (1) test for starch with iodine, (2) stain with Sudan III in alcohol, (3) sections left a few minutes in absolute alcohol to remove fat (oil) then stained with iodine or eosin for structure of aleurone grain. Test sections of cotyledon of bean or pea for character and relative amounts of food.

8. Bacteria. Forms from cultures decaying peas, infusions, etc. Spore formation from cultures of Bacillus subtilis. Observations on flasks of milk, (1) left open at room temperature and in ice box, (2) plugged with cotton, pasturized by heating to 65° C one half hour, kept at room temperature, and in ice box (3) plugged, heated to 98° C one half hour, kept at room temperature, (4) plugged, heated to 120° C fifteen minutes, kept at room temperature. Root tubercles on clover.

9. Yeast. Structure from cultures in very dilute molasses. Experiments on fermentation.

10. Simple algae such as Gloeocapsa, Pleurococcus, etc.

11. Spirogyra. Detailed study to cell structure, plasmolysis. Conjugation.

12. Vaucheria. Structure and reproduction.

13. Fucus. Structure. Fertilization on the slide. Substitute for Vaucheria if material is available

14. Rhizopus. Structure and life habits. Zygospore formation from cultures or from slides.

15. Microsphaera. Life habits, ascocarps.

16. Corn smut or loose smut of oats (brief study).

17. Wheat rust. Life history with examination of uredospores, teleutospores, and aecidia on barberry (slides).

18. Mushroom. Morphology and life habits. Demonstration of bracket fungi, puff balls, etc.

19. Moss. Thorough study of life history to establish alternation of generations. Discussion of chromosome reduction.

20. Marchantia. Brief study, emphasizing the small sporophyte.

21. Sphagnum. Brief study and discussion of life habits.

22. Fern. General morphology of sporophyte, structure of sporangium and development of spores (slides). Detailed study of prothallus, motile sperms, fertilization, young sporophytes. Life history thoroughly worked out

23. Selaginella. General morphology (briefly). Comes in detail. Life history explained.

24. Equisetum and Lycopodium. Brief study or demonstration.

25. Pine. General morphology. Staminate and carpellate cones. Slides of gametophytes about thirteen months after pollination. Pine seeds, demonstration of seedlings.

26. Flower. Structure of one or more types.

27. Anther and pollen development. Slides of lily anthers with several stages.

28. Ovary, ovules and embryo sac. Slides of lily ovaries.

29. Embryo and endosperm. Slides of lily.

30. Seeds and seedlings. Morphology and germination, bean, pea, corn.

31. Fruits. Demonstration and discussion.

The endeavor is made to put students promptly at work on concrete matter and make them by quiz and discussion do some reading and thinking. The first part of the course deals with the work of the seed plant, developing fundamental principles of plant physiology based on a study of structure. This is followed by a series of type studies with emphasis on the work and life habits of the fungi, and developing for the green plants the idea of a sequence or evolution of types. Life histories are worked out carefully from the bryophytes on, and there is thorough drill on the essential homologies between seed plants and pteridophytes. An understanding of the flower is reached by way of the pteridophytes.

Digitized by Google

The laboratory studies are planned to cover sufficiently the ground of a text book and the students by quiz work are held to a careful reading and understanding of the text, digging out for themselves the fundamentals of the subject. The lectures are chiefly upon subjects less satisfactorily treated in the text and the course endeavors to reduce formal lecture work to a minimum, substituting for it quiz and class discussion in sections of not more than twenty five students.

Some optional field trips are arranged for students willing to put in extra time but no attempt is made to attract the attendance of students with little or no interest in the subject since such are frequently disturbing elements in the success of field work.

With this the publication of outlines in the hands of the writer is brought to conclusion. The twenty which have been printed are a selection from more than twice as many received and fairly represent the diversity of conditions for which introductory courses in botany are framed and the radical differences of opinion as to material and methods. With conditions so varied in the schools and colleges it is clear that there can be no standardization of the introductory course. Progress will be made by experimentation and will be hastened with the interchange of experience and suggestion. It is hoped that the publication of these outlines has been of some help in this direction.

HIGHEST MOUNTAINS IN IDAHO.

Hyndman Peak is the only named mountain in Idaho that rises above 12,000 feet. It stands near the Blaine-Custer county line and has a height of 12,078 feet. There are, however, several unnamed peaks near Hyndman Peak whose elevations are greater than 12,000 feet, as shown by the contours on the Hailey topographic map, published by the United States Geological Survey.

PROMISING OIL WELLS IN SOUTH-CENTRAL ARKANSAS.

For the last few years geologists have conceded that oil and gas may be found in commercial quantities in southern Arkansas. The formations there are practically identical with those that yield oil and gas in northern Louisiana and the location of the area with relation to the Ouachita and Sabine uplifts indicates that there is in that area favorable anticlinal structure comparable to the anticlines beneath which the Caddo and Homer pools were formed. Development was retarded, however by lack of detailed mapping which would have shown the relations of the beds of southern Arkansas to those of Louisiana for it seemed possible that a fault, known as the Alabama Landing fault, which had been observed in northeastern Louisiana extended across southern Arkansas, and that the beds north of this fault had dropped down so far that the oil-bearing beds would be below the reach of the drill. Recent developments have shown that this fear is groundless, and there is now ample encouragement for active wildcatting in this region. The beds are of the same age as those that bear oil only a short distance to the south; the structural relations indicate that anticlines and domes should exist; and most important of all, tests have actually discovered good showings of oil and have developed gas in paying volume.

Digitized by Google

THE DISCIPLINE OF EXPRESSION.

By Max J. Herzberg,
Central High School, Newark, N. J.

The recent discussion in School Science and Mathematics as to the causes of poor English in the oral and written work produced in the science and the mathematics classroom fails, if I may say so, to consider one important aspect of the question —the psychology of expression. The problem turns on the nature of thinking as limited by its statement in words.

"What is thought?" asks Anatole France, "and how do we think?" And he replies: "We think with words." A person employing words is engaged in very definite mental processes, and some students of the human mind have confirmed Anatole France so far as to say that thinking itself does not exist until it has been formulated in language.

As one writer has stated: "People say sometimes, 'You know, I have an idea if I could only express it,' but they forget that thought is born in language and that thought does not exist without words, and that anything which cannot be expressed is not. They forget that consciousness only begins with a spoken communication, and that there is no such thing in the world for useful purposes as an idea that cannot be expressed, and the very usefulness which we have is limited to the possibilities of our expression. There is little use in being sincere if we cannot translate."

Language, as Jung in his "Psychology of the Unconscious" points out, should, however, be comprehended in a wider sense than speech. In other words, the whole process of intelligence is accompanied by an undertone of words, phrases, and sentences—broken or whole, continuous or disjointed. Apply this to the process of teaching; and it will be obvious how absurd it is to confine to one hour of the day the business of instructing students how to handle words. In the sentence of Robert Louis Stevenson, "The problem of education is two-fold; First to know and then to utter." To keep instruction in utterance within the bounds of the English period means merely that for only that single hour each day students are being instructed how to think.

It is impossible to teach a student the laws of the angles of a triangle or the parts of a flower or the mechanism of a pattern or the chemical constituents of food, without teaching him the use of words. No teacher can escape his destiny. In his zeal to impart merely the facts of his subject, he may deliberately

Digitized by Google

neglect the rules of clear and compact expression, for example. If he does he must inevitably find that the very facts he sought to teach have somehow been eluded by the student. It may then be laid down almost as a definition that in the so-called academic subjects, one of the prime objects of education is to train the ability to think clearly as shown in clear expression. The mother tongue in such a definition is merely the flexible medium of all expression, and is equally significant to all teachers at all times.

It may be inquired, What shall be said of the technical subjects? So far as the academic portions of such subjects are concerned—the recitation, the examination paper, etc.—no difficulty, of course, arises. But it is a common misconception that academic subjects involve high intellectual activities, whereas technical subjects do not. It may, on the contrary, be maintained that it is probably more difficult and not less difficult to understand the workings of a carburetor or the proper relations of the nutritive elements than it is to understand the construction of a Spenserian stanza or the principle of a subjunctive of purpose. The time may indeed come when a process only too familiar in our days will be reversed. In those revolutionary times the vocational counselor of the city's school system will come to a boy failing in a technical course and will say to him: "My boy, I am afraid you are not quite brainy enough for a technical course. You had better be transferred to an academic course or to an academic high school."

The only problem at present lies in the fact that the technical subjects have been for so short a time a part of the school curriculum that their intellectual content has not as yet been reduced to method. Here a proper realization of the value and conception of the mother tongue cannot but help. Teachers of technical subjects, just because these subjects are more difficult than academic subjects are, must more than other teachers insist on clear and careful expression.

I know the reluctance some teachers may feel with respect to receiving such a conception of the mother tongue. It may imply to them the constant and everlasting application of pettifogging rules and regulations, which hitherto they have left to English teachers, not without a profound sigh of relief. I admit that it is with a certain measure of complacency, on the other hand, that the English teacher would contemplate a wonderful state of affairs in which it would no longer be possible for the

Digitized by Google

student to abuse his e's and i's in *receive* when writing for the history teacher, and to reel off nonchalantly his "I seen" and his "I done it" to the gymnastics teacher, and then to come to his English teacher and regard him with wondering eyes as a queer fossil survival of the First Glacial Era. But I did not have these minor points particularly in mind. May I quote in this connection the words of Prof. Thomas H. Briggs of Teachers College, who says:

"It is felt by many that English teachers give to pupils an indelible impression that criticism means a hostile scrutiny of details, whereas the duties of life will demand of them positive merits—the manifestation in their compositions of such qualities as sincerity, definiteness, unity, coherence, variety, and the like. I myself have an ingrained horror of violating many detailed rules of dictation or of grammar, but sometimes I am heretical enough to wish that I had an equally ardent desire and the c rresponding ability to master my subject, to seek the truth consistently in discussion, and to organize such thoughts as I have so that any intelligent hearer may perceive each one, fully understand it, and comprehend how in relation to the others it contributes to a worthy end." The ideal of the reader of compositions and of the hearer of recitations, in any subject, should be that of Baldwin: "To be a promoter rather than a proof-reader." Nor does cooperation with the English department mean, as one writer has put it, that the teacher in another department should pester pupils concerning such errors as he himself is conscious of not committing.

Nor is it necessary to be dogmatic as to special devices, the complete sentence in reply to questions, for example. What it is suggested teachers do, so far as teaching the mother tongue is concerned, is not to hunt with a microscope for grammatical errors, nor yet to insist on a rigid ceremonial in recitations, but rather to direct pupils' thinking on the plane of language. The average teacher, moreover, as he faces the average pupils, is not confronted with the task of helping in the development of literary geniuses. He is only to be properly conscientious as to the pupil's use of the mother tongue, and so far as his own subject goes, he is to demand a unified, methodical presentation of facts. The student consequently may learn more of the art of clear thinking and expression in the geometry class and more of the niceties of language in the Virgil class than he does in his contemporaneous English class. Moreover, as I know from

Digitized by Google

personal experience and observation, such is often the case. So the teacher in any subject may say to the student: "If you make grammatical blunders, it proves that you are not mature enough to realize the value of your mother tongue. We shall consequently keep you in your present English grade until you grow up. If, on the other hand, your presentation of the facts and principles of physics or cooking or mechanical drawing or economics is confused and obscure, it proves conclusively that you have been guilty of a crime of deeper dye—the crime of not understanding *me;* and so of course I shall certainly keep you here in my class for a sufficient period longer."

For the definite work of cooperation, the plan in use at the Cicero, Ill., high school seems the best. This, as it is described in accessible records, I recommend to the attention of interested readers.

OUTSIDE OF CLASSROOM ACTIVITIES IN SCIENCE.

By L. C. Feldmann, *High School, Oshkosh, Wis.*

W. L. Lane of the Survey Staff after a detailed study of the English school system under war conditions made the following statement:[1] "One good has, however, come out of all this"—referring to the use of school buildings for barracks—"and this is the *school journeys* that have been resorted to in order to fill in the time which can not be spent in the classrooms." Referring to a particular class, in which outside work had been done, he said: "Within six months the class had become so much more alert and interested in its work than it had been before, that the instructor begged to be permitted to continue these journeys even after the school had been restored to its educational use." In order to determine the extent to which these methods are employed, the following questionnaire was sent to Wisconsin High Schools, chosen at random out of the school directory issued by the State Department of Education.

Out of the forty-eight letters sent out, thirty-seven replies were received. In two cases the information obtained was of an indefinite nature, and consequently has not been included in the tabulations.

In answer to my request for personal letters only three schools, numbers 8, 11, and 36 responded. In each case the writer excused the small amount of outside activity because of the shortness of the periods and because of the prohibitive amount of work on the part of the instructor.

[1] Survey, Feb. 3, 1917.

Digitized by Google

Dear Fellow Teacher:

I am enclosing a set of questions which I wish you would fill out and return to me in the enclosed stamped envelope. If some of the subjects mentioned are taught by some other teacher, will you please obtain the information from that teacher, and then fill in in the proper spaces?

I should appreciate a personal letter stating more in detail what you are doing in the line of outside activities in connection with your science work.

1.

Class	Approx. Number of trips.	Where to are trips taken
Physics		
Botany		
Ele. Science		
Agriculture		

2. Is there a Science Club or similar club in your school?
3. If so, what is accomplished by it?
4. Number of members? (b) Number of pupils in school?
5. Are any attempts made to create an interest in science in pupils who are not taking any science subjects?
6. What are they?

In reply to the first excuse I can only say that if the periods are so short that trips cannot be undertaken in the allotted laboratory time, the curriculum has not been properly balanced, and should be rearranged. However, I have found a double period of forty minutes each affording ample time for all ordinary excursions. And under exceptional conditions different arrangements can be made. As for the teachers having too much work, if that is the case; then the teaching force should be enlarged, for we cannot afford to have the rising generation taught in a helter-skelter fashion. The problems the men and women of tomorrow will have to grapple with will be too difficult to solve with such a preparation as a foundation. However, it is my firm conviction that the overworked teacher would find relief in taking a physics class to the power plant or to the telephone exchange and have the person in charge of the plant explain the workings of the same. In order to prepare a lesson of this kind all that is necessary is to telephone for permission to visit the respective plants and arrange for a guide. Surely, this is not so much work and does not take as much time as is required in preparing the regular laboratory exercises.

Thus much for the excuses. More interesting conditions are revealed as the answers to the six questions are compiled.

Tables I and II take in all the data under question I.
In tabulating the results, the total obtained by adding the number of trips taken by each class in that subject was divided by the number of classes entering into the making of the total; thus giving the average. For example, in physics the thirty-

Digitized by Google

TABLE NO. 1.		NO. OF TRIPS TAKEN IN:			
School Number	Approx. Enrollment	Physics	Botany	Elem. Science	Agricultr.
1	70	4	10	4	7
2	39	1	2	0	3
3	265	1	3	0	8
4	20	4		0	7
5	90	1		0	2
6	65	0	2	2	3
7	83	2	5	0	2
8	105	1	0	0	10
9	120	2	6	2	6
10	125	1	0	5	
11	99	0	0	0	0
12	72	0	18	0	26
13	80	7	7	8	0
14	810	0	0	0	2
15	109	5	0	8	15
16	310	5	15	4	14
17	400	2	0	0	0
18	135	4	12	0	10
19	120				
20	800	3	4	4	50
21	270	4	4	2	7
22	75	1	12	4	3
23	46	1	3	0	8
24	240	4		2	2
25	25	0	0	1	3
26	95	2	7	3	6
27	75	1	0	1	
28		2	5	0	2
29	105	0	19	0	21
30	115	7	8	7	0
31	130	0	2	0	0
32	89	8	15	5	14
33	78	2	0	0	1
34	83	4	6	4	5
35	460				
36	216	1	0	0	1
37	280	4	10	3	4
Total No. of Trips.....		84	175	69	242
Average No. of Trips.....		2 2-5	5	2	7
No Trips Taken		7	10	10	5

five classes took eighty-four trips; or each class took an average of two and two-fifths trips. Seven, or one-fifth of the classes, undertook no trips during the year. In botany the average number of trips is five per class, yet ten teachers taught this subject for which much illustrative material in natural environment is always close at hand without any attempts to utilize it. Elementary science shows an average of two trips per class, but in this case, half the classes went on no trips. Agriculture, a subject which calls for much field work in order to get away from the non-vitalized type of instruction of ten years

Digitized by Google

Table No. II
Where Trips were Taken to by Class in:

Physics	Botany	Elementary Science	Agriculture
1. Electric Plant	1. Woods	1. Factories	1. Farms
2. Telephone Exchange	2. Field	2. Asylum	2. Feed Mill
3. Paper Mill	3. Truck Farm	3. Condensory	3. Elevator
4. Saw Mill	4. Greenhouse	4. Marble Works	4. Stock Farm
5. Dam	5. Lake	5. Coke Plant	5. Machine Shop
6. Garage	6. Fish Hatchery	6. Drug Store	6. Fair
7. Tractor Factory	7. Parks	7. Bakery	7. Corn Field
8. Machine shop	8. River or Brook	8. Photograph Gallery	8. Woods for Grafting
9. Water Plant	9. Orchard	9. Water Plant	9. Creamery
10. Power Plant	10. Garden	10. River or Brook	10. Gardens
11. Print Shop			
12. Telegraph Office			

ago, has an average of seven trips per class. Even here, five teachers have made no attempts to vitalize their work by this method.

In Table II a list of the places mentioned by the different teachers as having been visited by their classes has been made. Under physics twelve specific places are mentioned of which numbers 1, 2, 6, 8, 9, 10 and 12 are usually found in any village or city. Botany and agriculture have a very general list with probably numbers 3, 4, and 6 the only places not found in every community. In elementary science where ten specific places are mentioned and two are the average number of trips undertaken, some other reason for this lack of outside activity must be found. Keeping this in mind, note schools number 12, 13, and 29 in which the four subjects mentioned are taught by the same teacher.[2] Number 12 shows no trips in physics or elementary Science, 18 in botany and 26 in agriculture; number 13 gives physics 7, botany 7, elementary science 8, and agriculture 0; number 29 has the following record; Physics 0, botany 19, elementary science 0, agriculture 21. The records for schools numbers 12 and 29 seem to indicate that the teacher's particular field was agriculture and botany. Upon further inquiry this was found to be true.[3] In both cases the instructor had majored in agriculture in college. School number 13 has a record which points to agriculture as the slighted subject. And in this case it was found that the teacher had had no college or practical training in agriculture and taught the subject because the

[2] Verified by personal interview.

Digitized by Google

science man was supposed to do so. These results, although meagre, seem to indicate that a teacher can teach only those subjects in which special training has been received, and that some subjects are taught by teachers not adequately prepared to teach them. Now then, let us again think of elementary science. Perhaps in the fact that no special training to teach such a subject has been offered by the college and universities and that it has not been given much of a place on the sectional programs of the leading teachers' association meetings, can be found the reason for the poor record made by it. Or is it perhaps because elementary science, to a great extent, is taught by teachers who would rather work in their chosen fields; such as physics, botany, or agriculture?

In answer to question 2, six schools indicated that there was an agricultural club in the school, and thirty-one stated that they had no club of a scientific nature. One instructor in answer to this question made the following statement: "With a literary society and debating club it does not seem advisable." Here the impression is given that the attitude, "I'll take care of everything else first, and then comes science," prevails. What the clubs accomplished can best be judged by several answers to question 3 which follow: (1) meetings are held semimonthly and topics pertaining to agriculture and poultry are discussed by students; (2) discussion of current farm improvements and study of farm magazines; (3) garden and field projects are undertaken. In each case a marked improvement in alertness was noticed among the students belonging to the club.

The number of members ranged from 15 in the smallest to 40 in the largest club. The average membership for all the clubs was 28.

Like question 2, questions 5 and 6 do not net much information outside of the fact that very little is done outside of the classroom to interest students, and that a few are opposed to such methods. However, in sixteen instances the opinion expressed was that something not included in classroom work should be attempted. Often this opinion was expressed in unmistakable terms. For example, instructors in schools number 6, 14, and 25 answered thus (school 6): "Not as yet *but there should be*"; (school 14): "Outside work a sadly neglected feature here"; (school 25): "*No*, but something *ought* to be done." In a few schools some attempts are made. School number 9 reports that opening exercises are given over to the discussion of science subjects

Digitized by Google

one of the features being to have the person in charge give questions to be reported on later, the answers to these questions to be found in *Popular Science*. The instructor in school number 22 places newspaper and magazine clippings of scientific interest on a bulletin board and encourages students to bring to him clippings of the same nature to be placed on the board.

Both of these methods are very good and should be more generally used. However, in large schools such methods do not reach all the students, because no general assembly is held every day and not all students visit the class room where the bulletin board is found. Another very good way of reaching the pupils in a school of any size is by means of exhibits.

These exhibits, which will be explained later, should be placed somewhere in corridors near the main entrance, or better still if possible, in some particular place in the library. It is an advantage to place them on a small table or stand used exclusively for the purpose of the exhibition in some well-lighted space, but if necessary, less favorable positions afford sufficient opportunity. A bulletin board immediately behind the table or stand is convenient for pinning up clippings pertaining to the articles on exhibition. A fairly large card or label conspicuously placed on the table or near the top of the bulletin board, naming the project and indicating when changes in the exhibit are made is desirable. As a means of exciting the interest of those who do not take science it is advisable to change the display once a week, preferably on Saturday; but if there is a shortage of illustrative material, a two weeks period is not too long.

In order to help out in this respect the following list of exhibits used by the author and found of interest to the pupils is given:

1. (a) Cecropis moth. (b) Blazing Starflower. (c) Picture of song sparrow.
2. Asbestos and literature on same.
3. Horlick's malted milk exhibit.
4. Blue print pictures and how to make them.
5. The ores of different minerals.
6. X-ray picture and literature on electric treatments.
7. (a) Specimen of frog. (b) Several balls of cotton. (c) Picture of robin.
8. Coffee in various stages of preparation.
9. Several different specimens of fungi.
10. How to mount butterfly or moth (the various steps).
11. (a) Zebra swallow-tailed butterfly. (b) Several clams and oysters in the shell.
12. (a) Closed Gentian. (b) Giant water bug.
13. Standard Oil Products exhibit.
14. (a) Pickerel weed. (b) Sea urchin. (c) Picture of gold finch.
15. (a) Synthis moth. (b) Blue jay picture. (c) Starfish.
16. Collecting, pressing and mounting plants.
17. Collecting of rocks.

Digitized by Google

18. Artificial fertilizer and effect on plants.
19. How to prepare any small insect for permanent collection.

This list can be supplemented to a great extent. For example, the experimental field has not been touched and under this, besides many others depending on the laboratory apparatus on hand, the following can be shown:

1. Petri dish experiment to show presence of bacteria on different articles.
2. Testing of cloth for adulterations.
3. Copper-plating of a spoon or fork.
4. Illustration of the difference between an acid and a base by action on indicators.
5. Refraction of rays of light by means of a pencil placed so that it is partly under water.

In each case an appropriate non-technical explanation for each article was given on a four by six card. There was no pretense at arranging the exhibits in any definite order, for it was found advisable to have each exhibit complete in itself rather than have a course of exhibits. By experiment it was found that the present system created more interest in a larger number of pupils than the course of exhibits did.

In conclusion, I will say that I have tried to give to the reader in concrete form the data gathered from other teachers, together with my interpretations, and also those methods which I have found successful while teaching.

COMMERCIAL GEOGRAPHY AS VOCATIONAL GUIDANCE.

By Andrew Nichols,

Austin High School, Chicago, Ill.

The daily papers on a recent Sunday showed that the labor market of Chicago demanded men in the following vocations which might be classed as office work: Certified public accountants, cost accountants, senior accountants, bookkeepers, billers and extenders, ledger clerks, cost clerks, general office clerks, adjustment correspondents, addressers, foreign correspondents, mailing clerks, adding-machine operators, railway clerks, stenographers and typists, advertising men, credit and collection men and manager, clerks for insurance offices, bank clerks, placement men for employment agencies, office engineers, office managers, special credit men for banking houses, insurance executives, advertising managers, health and accident club managers, interpreters for professional offices, and time keepers.

In the mercantile field there were calls for buyers and assistant buyers, advertising solicitors, stock clerks and receiving clerks,

Digitized by Google

floor managers, billing department managers, window trimmers, sales managers who know United States from the distributing viewpoint, man for import and export trade, examiners, Chicago agent for N. Y. cotton house, shipping clerks, order fillers, and checkers in wholesale houses, order pickers in mail-order houses, district sales managers, salesmen both counter and traveling for groceries, hardware, fountain pens, jewelry, real estate, optical supplies, millinery, motion picture films, draperies, dress goods and silk, furs, shoes, talking machines, electrical appliances, automobiles, auto tires and accessories, drugs, bonds, candy, soap, toilet preparations, creamery and dairy supplies, lubricating oils, food products, pencils, washing machines, and vacuum cleaners: "Puff Waffle" merchants.

In the production world the following trades were in demand: templet makers, tinsmiths, tool makers, watch makers, welders, pattern makers, repair men, wood workers, assemblers, bakers, battery men, bench, floor and squeezer molders, blacksmiths, book binders, bushelmen, butchers, cabinet makers, compositors, cutters, pressmen, dick mailers, die makers, engravers, feeders, furniture grainers and finishers, gear cutters, glass workers, machinists, men skilled in marine engine construction, wood workers on musical instruments, meter testers, lathe men, iron and brass molders, linotype operators, scale men, spinners, soap makers, steam fitters, stationary engineers, tablet men, foundry superintendents, auto trimmers, auto mechanics, tailors, auto and machinery inspectors, and various classes of shop foremen.

Openings in the more strictly technical lines and professions were not as numerous. There were, however, some calls for architectural, topographical, tool designing, mechanical, and automobile draftsmen, electrician for motor and generating station work, engineers, designers, research technical men, teachers for electrical and automobile courses, commercial photographers and free-hand artists, dentists, attorneys, secret service men, appraisers, market reporters, and chauffeurs.

Some miscellaneous offerings, difficult to classify, are perhaps worth mentioning: Man for pawn-shop, man to learn theatrical scenery painting, man to instruct and teach the use of the moving-picture camera, men for the merchant marine, elderly man with white mustache and beard to act as Santa Claus.

The openings for boys showed much less differentiation than those for men. Boys were wanted for delivery work, errands,

Digitized by Google

order fillers, assistant shipping clerks, light electrical assembling, to stamp parcel post packages, to bind books, and as apprentices in various trades. The usual bait, an "opportunity to learn the business," was held out in a great many cases.

The demand for women and girls showed less minute classification than that for men, but more than that for boys. The demand was greatest for stenographers, bookkeepers, typists, filers, general office girls, cooks, house-maids, nurses, saleslaadies, cashiers, dictaphone operators, waitresses and seamstresses. There were scattering calls for addressers, circular folders, billers, assistants in doctor's offices, comptometer and multigraph operators, entry clerks, ticket writers, timekeepers, switchboard operators, photo engravers, book binders, mailers, foreladies, secretaries, women to sort and cut pickles, pack bakery goods, electrical assemblers, girls for filling, cartoning and labeling bottles, packers and wrappers, stock girls, paper flower makers, lamp shade makers, beauty shop operators, button makers, candy makers, designers, hat trimmers and manicurists, monotype operators, drapers, demonstrators, salesmanagers, music teachers, inspectors, industrial nurses, traveling salesladies, "Human Interest" librarian, and woman for vocational placement.

This bewildering array of positions open on one day in Chicago gives a fair picture of the business world as it appears to the boy or girl the day after graduation from high school. Is it not true that a man has two great decisions to make in life: One, the choice of his vocation; two, the selection of a girl to be his wife. (After these are made, she makes all the rest.)

I believe commercial geography is fitted to give the student much help in making the first of these decisions. If a commercial geography teacher, or anybody else, attempts to give a student too much so-called "guidance," either vocational or matrimonial, he will rightly fail. Business men make their own decisions. Boys and girls expecting to enter business must do the same. Vocational information, not advice, is what they want.

Information concerning the relative opportunities in the various vocations and the general distribution of the demand for labor in each is not obtainable in the average Chicago home today. It is therefore the function of the public schools to give the boys and girls this data before they are obliged to select their first regular employment.

As a means of experimentally discovering how much the average Chicago boy or girl knows about the real nature of

Digitized by Google

vocations, I unexpectedly asked the pupils in my classes one day to write a brief description of their fathers' work. To make it a fair test and to avoid diffidence, I told them they need not sign their names. Many freely admitted that they did not know their fathers' business. The reasons for this condition are not hard to find. Life in a large city is complex. Economic employments are not carried on in or near the home. Social engagements are very exacting. Office and shop employment has become highly specialized.

In less complex social and economic units, vocational information is much more easily obtained. Work is done nearer the home. The smaller the industrial unit, the more visible are its operations. The home life of the farmer has more influence on the children than the home life of industrial classes in the cities. The country boy or girl daily sees and comes in contact with all the vocations common to a rural community. This acquaintance with industrial activity must come to the city boy largely through the influence of the press, libraries and the schools.

If the school fails and the pupils are allowed to drift into work by chance or proximity, there is tremendous waste occasioned by the misfit of getting into the wrong employment. This results in a high percentage of inefficiency and change in the working force of every large concern, the waste of time, money and training and a general low grade of service. Every person who remains in the wrong employment is doomed to moderate usefulness and early incapacity. Usually, however, vocational misfits are corrected after much loss of earning and learning capacity in drifting from job to job while securing a knowledge of the world's work that could and should have been obtained at school.

Even after the drifting process has gone on for two or three years the final employment, though not a complete misfit, is often only a partial adjustment of ability and interest to resources and opportunity—a life investment much like the investment of money at a low rate of interest. The work that the individual would like to do best and at which he would be the most productive is side-tracked into the evening hours or pushed out of his life altogether. Life is worth more than money (anyway a person won't sell it); it should, therefore, be invested on the best return of the capital put in.

Of course, the object of all vocational guidance is to show the individual how to test himself in connection with his opportunities, to see where he can best invest his particular capital.

Digitized by Google

It is my own belief (maybe I am wrong) that such work in the past has laid too much emphasis on self analysis and too little on a careful survey of the larger relations of industrial and commercial life. Biographical data of leading business men today seems to show that the successful man is in the business that he is because he "likes it" and not because he showed any special qualifications as a boy for his particular work. Associations formed on various summer jobs covering the last fifteen years have convinced me that the converse of the proposition is also true—that the reason for the misfit is that he "hasn't found anything that he likes." Efficiency and success are largely a matter of interest.

Interest or lack of interest in any particular vocation or business is more likely to be due to knowledge or ignorance than to demonstrated capacity. This will often explain why an Illinois farm boy who knows all the "outs" of his father's business comes to Chicago and is lost in the mass of moderately successful industrial workers, while a Chicago boy who knows something of the intensity of city competition in industrial lines, leaves real opportunity, goes into the country and settles down to earn money to buy the farm that the country boy would have gotten by inheritance. Such relations as the above are clearly within the sphere of commercial geography instruction.

Commercial geography explains the world in terms of its usefulness to man. It is the point of contact between the sciences dealing with nature and social sciences. It is a study of the interdependence of the different parts of the world and the influence of location on the industrial and commercial life of man. Its primary object is not to teach vocations as such, but industries and commerce, and right here, I believe, lies the great opportunity of the commercial geography teacher for vocational guidance, because the great mass of the business of a large city depends on distant markets or distant sources of raw material and food products, and the dignity of an occupation is only felt as its relation to other occupations and regions is known.

I don't believe you can do a better service to boys and girls than to get them interested in industries rather than trades merely, for here is the point where ambition starts. Stenography and tool-making are not vocations for ambitious boys, although I don't believe there are any better means than these to use as entering wedges for forcing one's way into commerce or manufacturing. The idea "once a stenographer always a

Digitized by Google

stenographer" is not the basis of a wise vocational decision. If boys and girls, before going to work, get a larger interest in their chosen industries, they are more likely to feel a loyalty to their companies and less inclined to indulge in the luxury of quitting several jobs before finally settling down. This loyalty to the industry rather than the trade as a unit, which comes from interest and interest from knowledge will go a long way toward preventing industrial unrest and, incidentally, will go a long way toward the vocational advancement of the individual boy or girl concerned.

In order for boys and girls to get an accurate view of the world's commerce and industries from their work in commercial geography, that work must be in an environment of business and business journals. In a great national and international trade center like Chicago, opportunities for this are unsurpassed.

The first fundamental of commercial geography is exchange. Exchange is dependent on transportation and Chicago is the greatest railroad center in the world. Transportation and the exchange of commodities has become a science and there are almost infinite vocational opportunities attractive to a high school boy or girl as something worth working for in the administration of the general offices of a great railroad system or a large city passenger, or freight depot. Entire classes cannot readily be taken through such places, first, because of their numbers, and second, because it is wasteful to use the time of forty people to accomplish a result which can be gotten better by two. Here is a working plan: Two pupils are given a typewritten letter of introduction, directed to the highest official in the building, asking him to give them a guide to show them how the work in the general offices of a large railroad is carried on, so that they can tell their class about it. The two pupils are given a few simple instructions as to what to observe, two of these instructions being to try to see what the different classes of employment are and what seems to be the principal work of each. Often the guide will help them in this. These pupils make a formal report to their class. In my own classes I have had many reports of this kind which were very interesting and enlightening from the vocational guidance viewpoint. For example: My pupils have observed in practically all of the industries studied that men of all ages were employed but that there are only young women. This has given them visible proof of the economic fact that men should train themselves for

Digitized by Google

one vocation, and women for two; first, a temporary employment of a few years and latter a permanent employment, in most cases, as homemakers. I believe that a study of the sources of the world's supply of the commodities daily used in the home and the various channels of commerce through which they pass in getting to the consumer's door is good vocational training for any American girl.

Another significant fact which my students have noted is the large percentage of employees in a commercial market like Chicago who are engaged in the buying and selling of goods. Clerical training of the business college or "clerk factory" type does not train to buy and sell goods.

Another thing of still greater importance which they have discovered is the relatively small number of men in business who are products of the commercial courses in our high schools. This is only another angle of the situation disclosed in the commissioner of education's report of any year in the table on commercial education; where we find that Chicago has a surprisingly low percentage of boys taking commercial courses in the high schools, as compared with other large cities. Ex-Mayor Harrison's commission on commercial education noted the same fact and recommended the building of a central commercial high school in Chicago, which would train boys as well as girls for business.

The movement of commerce in and through Chicago presents many phases of our peculiar geographical environment which can be utilized to light the way to vocational opportunity. The largest packing houses in the world are here, offering a hundred different grades of responsible employment, varying from office and clerical positions to representatives in foreign markets or buyers in South America.

Some of the largest wholesale houses in the country are on Franklin and Market Streets, illustrating the specialized forms of employment to be found in a great distributing center.

The harvesting machines of the world are made in the plants of the International Harvester Company and there the student in commercial geography can learn at first hand the work and the requirements of the various specialized vocations connected with world trade.

The mail order business made profitable by the parcel post is revolutionizing the retail business of the country, an illustration of the ever-changing adjustments which are being made in the

Digitized by Google

field of commercial geography, and here again the Chicago boy or girl who sees a life opportunity in mail order work can learn at first hand by the laboratory method.

One of the phenomena of commercial geography is the gathering together of great masses of people in centers of general industry like Chicago. Such a vast population means a great and varied local market. The department stores and smaller retail units afford a ready means of studying this phase of business activity with especial reference to the vocational opportunities which it presents.

Although the influence of accumulations of capital and financial institutions is not, strictly speaking, a physical condition of commerce, most writers of commercial geography treat them as within the sphere of the subject because their geographical situation is often a determining factor in the location of industrial units and commercial establishment. The Federal Reserve, National, and State banks of Chicago have many attractive openings for boys and girls who are more interested in banking as a life work than in the question of initial salary.

This only illustrates the possibilities for field work as a part of commercial geography instruction. The class is a clearing-house into which are brought the various items of vocational information and interest which are gathered by the different groups of pupils as they visit these and many other units of commercial activity as their study of the topics of commercial geography brings them home to Chicago.

We are fortunate in having other means of creating interest in the industries which go to make up our economic life. Mr. Hayes, at the Board rooms, thru the liberality of the Board of Education has been enabled to get together a very complete collection of sets of lantern slides illustrating commercial geography. These slides have been collected with an idea of instruction rather than entertainment, and many of them furnish vocational information. Seeing them on the screen is almost equivalent to going thru the establishments which they portray.

To be of the greatest value as vocational guidance, commercial geography must not only have an outside environment of business; it must also be in an immediate environment of business journals. We are preparing the great majority of our pupils for business and not for the university. The business man gets his information from technical and trade journals, not college text books. If commercial geography teachers overlook

Digitized by Google

this fact, they are neglecting the very best means of vocational guidance. Such journals are: "The Daily Trade Bulletin"; "The American Grocer"; "International Sugar"; "The Tea and Coffee Journal"; "The Iron Age"; "Black Diamond"; "American Lumbermen"; "American Wool and Cotton Reporter"; "Shoe and Leather Facts"; "India Rubber World"; "American Machinist"; "The Electrical World"; "Engineering and Mining Journal" and the more general magazines like "The World's Work" and "Technical World"; also the Reader's Guide, an index of magazine articles.

The commercial geography teachers of Chicago and elsewhere are using these and other means to give their students a view of the commercial world before they choose their vocations. It is a large field. Mr. Vanderlip, the great banker, once said: "The eye of every business man must be far-seeing enough to observe all markets and survey all zones. A significant word spoken in any market place or parliament of the world instantly reaches the modern business man and he should be prepared correctly to interpret its meaning."

THE MATHEMATICS OF ELEMENTARY PHYSICS.

By Philo F. Hammond,

University of Wyoming, Laramie.

The body of a fish weighs thirty pounds, the weight of its head is twice that of its tail, and its body and tail together weigh three times as much as its head. How much does the fish weigh?

A farmer has a square farm enclosed with a fence four boards high. If the boards are eleven feet long and the farm contains the same number of acres as there are boards in the fence, how many acres are there in the farm?

To the casual observer the above problems are intended for exercises in algebra, but while it is possible that they could be used as such, they are not from that source. They are problems taken from a list that were used by our grandfathers as exercises in arithmetic in the old log school house, and while the second one may have been worked with pencil and slate, the first one belongs in the category of what was known as "mental arithmetic." Such problems have gone out of use so far as arithmetic is concerned, and perhaps rightly so since they have very little practical value. However, the pupil of those days received a training in analytical and independent thinking that our present system does not seem to give the pupil of today.

Digitized by Google

But what has this to do with mathematics in elementary physics? Only this: The writer believes that the analytical method applied to problems in arithmetic in those days should be applied to the mathematics in elementary physics rather than the formula method too commonly used.

Of recent years there has been on the part of teachers in our high schools, administrators and others much complaint against so-called mathematical physics in our high schools. Not only can these complaints be heard in our schools and at teachers' associations, but they are used as a basis of articles in magazines and as arguments against the kind of questions used for college entrance examinations. They are directed against textbooks and teachers of physics in general and especially against the training given such teachers in our colleges and universities. Some writers have even gone so far as to say that they would choose the physics teacher from the untrained in physics so as to get away from the sort of training given to the prospective teacher by the higher institutions.

Let us see how well these complaints are founded. Some physics texts will disclose the astonishing fact that about ninety-five per cent of all mathematics used in elementary physics is arithmetic, and it is safe to say that the teachers are few indeed who make their courses more mathematical than the books present the subject. In these texts there are but one or two simple quadratic equations used, and these in connection with accelerated motion. Many problems, to be sure, may be worked by either arithmetic or by the use of the algebraic method, but even if algebra is used, the equations are of the simplest form with only one unknown quantity. There are a few cases where geometry is applied, but these involve only a simple proof that two triangles are similar because they have equal angles and being similar their sides are proportional. Beyond this a fair notion of variation, as applied to such topics as Boyle's law and Charles' law, is required.

In our American high schools physics is seldom taught below the eleventh grade, and before entering the class in physics practically all high school students have covered two thirds of the algebra usually given in the high school and all of plane geometry, and, as has been pointed out, the mathematics used in elementary physics is very simple in its nature, involving but few simple principles in algebra and geometry. If one takes all of these facts into consideration, together with the fact of

Digitized by Google

the large amount of complaint against the mathematics in elementary physics, if there were no other conditions to be considered, one would be forced to come to one of the following conclusions: (1) Students cannot be expected to get anything out of high school mathematics except such mental discipline as may come from their work in the class room, and one has no right to expect them to use what they learn in the mathematics class room outside of that room; or (2) teachers of mathematics in the grades and in the high school do such poor work that their students are unable to apply what they learn in the mathematics class to any concrete problem outside. There is hardly any one who will concede the first proposition, but if we do not, is not the complaint against mathematics in elementary physics rather a condemnation of the mathematics teaching in our elementary and secondary schools than a condemnation of physics texts and physics teaching? It cannot be considered unfair for chemistry and physics teachers to expect their students to be able to use the principles of mathematics which they have studied, and if the student ever expects to use what he has learned, there is no better place than in the physics and chemistry classes for him to begin to do so.

It is not, however, the aim of the writer of this article to lay any blame to mathematics teachers, and while much might be said in regard to methods of improving the teaching of mathematics, it is not the intention of the writer to discuss this phase of the question as such. What is said regarding mathematics in physics will apply, perhaps, to mathematics in general, but this article is written for physics teachers, and not for mathematics teachers.

Going back to the problem above, students of arithmetic in those days applied what the writer prefers to term the "think method" rather than the method of formal mathematics. They followed through the problem using a method of reasoning which led them to the correct result without the use of symbol or algebraic equation. The mathematics teacher may say that this is useless kind of thinking, and perhaps it is since the problem itself may be classed as a useless kind of problem, but it gave exercises in the thinking process which when applied to various problems enabled the student of those days to solve problems that would bother many of the high school students of today. This "think through," or analytical method, should be the method applied to the solution of problems in elementary

Digitized by Google

physics. To illustrate this method one or two examples will be sufficient.

The physics teacher should not hesitate to teach the mathematics he wishes to use, no matter how much he may expect of the mathematics teacher. The application of Hooke's law is a good chance for the physics teacher to emphasize the principles of variation. This may best be done beginning with a concrete example. The following is data taken with a Jolly balance for a class for that purpose.

Pull of the spring in grams:	Elongation of the spring in centimeters:
1	5.9
2	11.9
3	17.9
4	23.7
5	29.7
6	35.5
Total 21	124.6

Examination of this data will show the student at once that the elongation increases as the force increases, and, therefore, $F_1/F_2 = E_1/E_2$. That is, F is proportional to E or $F = k \cdot E$. Whence $k = F/E = 21/124.6 = 0.1677$ gram or that it takes 0.1677 gram to stretch the spring one centimeter.[1] To test this if we multiply 29.7 by 0.1677, we get 4.98+ grams, or nearly five grams, the quantity given in the table. Also $2/4 = 0.500$ and $11.9/23.7 = 0.502$, that is to say $F_1/F_2 = E_1/E_2$, or $2/4 = 11.9/23.7$ approximately. The application of this principle to physical problems will be clearer to the beginner if we call his attention to the fact that this is not a new thing. If ten yards of cloth cost \$1.50, what will 25 yards cost? 30 yards? etc. After a few questions of this kind, the following table may be made:

Quantity of cloth in yards. (Q.)	Cost in cents (C.)
1	15
2	30
3	45
4	60
5	75
6	90
Total 21	315

Then we may say $C_1/C_2 = Q_1/Q_2$ or $2/4 = 30/60$ and C is proportional to Q or $C = kQ$, and likewise $k = C/Q = 315/21 = 15$ cents, and the constant is, therefore, the price per yard. When

[1]For the beginner this (force) constant should be determined by asking the question: "If 21 grams stretches the spring 124.6 centimeters, what force will be required to stretch it one centimeter?" For the sake of brevity only an outline of the development is given here.

Digitized by Google

possible these facts should be developed by questions before any algebraic expressions are used.

Accelerated motion is considered to be one of the most difficult parts of elementary physics. In many texts this is placed among the first topics in mechanics of solids, and when mechanics of solids is studied before mechanics of fluids, the student is confronted with a hard topic early in the course. The subject of accelerated motion will not seem especially hard to the elementary student if properly approached. The student is already more or less familiar with the idea of velocity. If a train runs between two stations 120 miles apart in four hours, how far does the train travel in one hour? The answer is quite obvious to most students—even to pupils in the grammar school. If a train travels at the rate of thirty miles an hour, how far will it travel in four hours? If a train runs for four hours at the rate of thirty miles an hour, how far will it go? The answers to these questions are equally obvious. No formulae are necessary. Attention should be called to the fact that what is meant is average velocity, that the train varies in velocity, and also that when we use the term velocity we infer a given direction as well as magnitude of the velocity.

This part of the discussion completed we may resort to an experiment if we so desire. The space that a ball rolls down an inclined plane may be determined for one, two, three, four, etc., seconds. The difference between these spaces is the space traversed by the ball for each unit of time. That is, the space covered by the ball from the beginning to the end of the first second, and from the end of the first second to the end of the second second, etc., etc., is the average velocity of the ball for that respective unit of time since it is the space covered in that unit of time. It will be seen that these average velocities are not equal, and if we get the difference between the first average velocity and the second average velocity, and between the second and the third, etc., etc., we have the increase in velocity per second which experiment shows in this case is practically a constant. This constant, or increase of velocity per unit time, we call acceleration. However, it is not the aim of the writer to discuss the experimental part of this topic. The nature of the experiment will depend upon the apparatus available. In whatever way we may approach the subject, the important thing is that acceleration is increase or decrease of velocity per unit time, or, to be more concise, change of velocity per unit

Digitized by Google

time is acceleration. If the thermometer registered thirty degrees twelve hours ago and now it stands at seventy, what is the change of temperature? What is the average change per hour? If the velocity of a moving body is twenty-four feet per second, and four seconds later it is 152 feet per second, what is the change of velocity? What is the change per second? If the velocity of a moving body increases at the rate of thirty-two feet per second, what will the total increase be in four seconds? If the student has not been handicapped by learning the formulae, he will follow this line of reasoning without difficulty, and no formulae or symbols are necessary.

We now enter the second stage of development; viz., to determine the space covered by the moving body. We have already shown that space is the average velocity multiplied by the time. The question now before us is to determine the average velocity. The average of anything is obtained by adding all of the quantities, the average of which is desired, and dividing by the number of such quantities added together. At this point it is well to resort to a diagram. Suppose we plot a curve with velocities as ordinates and time as abscissae. Since the velocity is increasing uniformly, the velocity is proportional to the time, and the curve, therefore, is a straight line. By means of this curve it is easy to show the student that there may be an infinite number of velocities, but in spite of this we may get an average, since the change of velocity is uniform. In this case it can easily be made clear that the same result may be obtained by taking the velocity at the beginning, and at the end of each second following, and we have $(0+32+64+96+128) \div 5 = 64$ feet per second. (Some student will probably suggest that if we take the velocity at the "half way" point, we will have the same result.) From this we can easily lead the student to see that if the first and the last velocities are taken the same result will be obtained, and thus we have $(0+128) \div 2 = 64$ feet per second. If the average velocity is 64 feet per second, how far then will the body travel in four seconds?[2]

Next let us suppose that the velocity at the beginning is twenty-four feet per second and the increase in velocity is thirty-

[2]The writer used this method of presenting accelerated motion ten years ago, and did not think of it as a new method, but had not seen it given in this way in any of the elementary text books, although some of the advanced texts use the substance of this method. Recently in looking over "Practical Physics" by Black and Davis he noticed for the first time that they use this method in developing the formulae for accelerated motion, but give the credit to Professor E. V. Huntington of Harvard University and consider it an entirely new method.

Digitized by Google

two feet per second; how far will the body travel in four seconds? The velocity at the end of each second is easily obtained from our diagram and the average velocity obtained as above is $(24+56+88+120+152) \div 5 = 88$ feet per second, or $(24+152) \div 2 = 88$ feet per second, and the space is $88 \times 4 = 352$ feet. So far, and not a formula nor a symbol used.

During all of this discussion the teacher has been using the term "thirty-two feet per second per second" without any explanation. Some student in the class will ask why the second "per second" is used. This is not taken up, however, until the subject is fairly well developed. Then the question is put: "If a body is moving at the rate of twenty feet per minute and increases its velocity to 120 feet per minute in a period of ten seconds, what will we say the acceleration is?" The students will give the correct answer at once.

Following this discussion the students are sent to the blackboard to work problems in accelerated motion, but no formulae are used. The writer has used this method for several years. It works well with students who have not studied physics before, and who have not learned the formulae. If the student has already learned the formulae, the task becomes difficult if not impossible. If there are students in the class (usually a small per cent) who have been well trained in algebra, and who have the algebraic conception fairly well developed, they will develop their own formula from this process of reasoning, and they will begin at once to use it. If the teacher so desires, he may, after giving a sufficient number of numerical problems, give problems using symbols instead of numbers and thus all of the members of the class will have developed the formulae. This should not be done, however, until a sufficient number of numerical problems have been worked to fix the principles thoroughly. With this method problems in which the initial velocity is not zero become as simple, even to the beginner, as problems usually given in elementary textbooks.

With problems involving the relationship $v = \sqrt{2}$ as this method becomes a little too difficult for the student to work the problems quickly and with ease. Such problems, if worked at all, should be left to the last. They may be worked without the use of the formula, but it is better, however, to develop the formula for the class.

Hooke's law as applied to the Jolly balance, and accelerated motion have been chosen as examples only, and have been

Digitized by Google

given in some detail to make the method clear. Accelerated motion was chosen as an example because it is usually considered as a difficult topic. It can be treated without the use of formulae, and with the student of elementary physics it is much better to so treat it. To be sure, students at this stage of development should be able to handle the elementary principles of formal algebra without much difficulty, but for the sake of the physics we as physics teachers cannot afford to use it in elementary physics more than is absolutely necessary. The student may need more training in the use of algebraic equations, but from our standpoint as teachers of physics it is the physical concept that he needs most, and that is usually what he does not get —especially if he learns a formula.

In physics, therefore, the "think method" is the one that will give the best results. With this method the student learns to think in terms of physics. It is a training, not a mere memory process, that will stay with him as long as he lives. The formal algebraic method depends upon the student's memory, so far as physics is concerned; if he forgets the formula as he will sooner or later, his physics disappears with it. The writer would prefer a text in elementary physics, if such a text could be had, with no formulae given, or with the formulae taken out of the body of the text and placed in a table in the back of the book so that the student could not study them in connection with the assigned topics. As it is he sometimes finds it necessary to caution students against studying certain parts of the text until that topic has been completely covered in the class.

The subject of physics has been developed by a few individual thinkers of exceptional ability—Galileo, Stevinus, Newton, Gilbert, Franklin, Faraday, Maxwell, and the others—who took the trouble to put the results of their thinking to the experimental test. Their thinking, of necessity, began with real concrete facts. Formal mathematics has, to be sure, played a tremendous part in the development of this subject; it has in many cases preceded and predicted important scientific discoveries as in the case of the Hertzian waves. However, the fundamental principles upon which Maxwell based his equations came from Faraday who used only the "think process" and who used no equations. Likewise the student who is just beginning in the subject must begin with concrete facts associated with the thing he already knows, and if he actually gets a grasp of the subject, he must follow pretty much the same process that the

Digitized by Google

pioneers followed, but his road, of course, need not be so long and tedious. Clear thinking must precede any attempt to use mathematical equations, much thinking must accompany any use of mathematics whatever and all must be put to the experimental test not after, but as an aid to, the thinking process. Description of apparatus and of how it works, of machines and how to operate them, or how to repair them if they get out of order may be of value, and courses of this nature may possibly have their place in the school curricula, but such a course should not be called physics for it is not a science unless the fundamental underlying physical principles are studied and in such a way that the student is required to do much individual thinking in applying these principles; and there is no better way, in fact hardly another way, to obtain this individual thinking on the part of the student than to require the application of these principles not only to problems that do not require a mathematical solution, but to a large number of problems that do require a mathematical solution. This can and should be done in the laboratory and in the recitation.

Summary:

Is elementary physics too mathematical?

By no means; the mathematics in elementary physics is after all mostly physics and arithmetic. Physics requires the student to think, unless it is the purely descriptive kind of physics that some teachers are trying to substitute for real physics to avoid thinking.

Do students like the mathematics of physics?

If properly taught, yes; unless they do not like to think. Some students do not; like many older people some either have not the ability, or are too lazy.

Does it pay to lead students to think?

Yes, there was never a time in the history of the world when real able thinkers were needed in all lines of work as much as they are today.

What then is the matter with the mathematics of elementary physics?

Too much formal algebra without application. Not enough of the "think process" used. It is easier for the teacher to require the student to learn the formulae than to actually teach the subject. It is a short cut for the student—the path of least resistance. It is a means of avoiding real thinking and therefore followed, unfortunately, by too many teachers.

Digitized by Google

PASCAL'S "NEW EXPERIMENTS ON VACUUM."

TRANSLATED FROM THE FRENCH BY WILLARD J. FISHER,

Woods Hole, Mass.

A letter of Pascal to M. de Ribeyre, "Premier président de la Cours des Aides de Clermont-Ferrand," is dated July 12, 1651, in which he complains that in the "Prologue" of certain theses on philosophy, read in the judge's presence, June 25, 1651, he had been accused of appropriating credit for the Toricellian experiment. He says:

"In the year 1644 some one wrote to Rev. Fr. Mersenne, Minimite at Paris, that the experiment we are discussing had been done, without specifying in any way who was its author. So in fact he remained unknown to us. Fr. Mersenne tried to repeat it at Paris, and, not being entirely successful with it, he stopped and thought no more about it. Then, having been at Rome on other business, and being exactly informed as to the means of carrying it out, he returned thence fully instructed.

"This news having been brought us at Rouen, where I then was, in the year 1646, we did this Italian experiment according to the directions of Fr. Mersenne, and having been entirely successful with it, I repeated it several times; and being by this frequent repetition entirely assured of its truth, I deduced from it consequences, to test which I did new experiments very different from that one, in the presence of more than five hundred persons of all sorts and conditions, and among them five or six Jesuit fathers of the College at Rouen. . . .

"To render to others and myself justice due, I had printed, in the year 1647, the experiments which I had done a year earlier in Normandy."

The above and the following are translated from Vol. III of Pascal's works, the edition of Hachette, 1872.

The "complete treatise" mentioned was never completed; only fragments of it are known.—[WILLARD J. FISHER.

TO THE READER.

My dear reader, certain considerations hindering me from publishing at present a complete treatise, wherein I have reported a quantity of new experiments done by me on vacua, and the consequences which I have drawn from them, I have decided to give an account of the principal ones in this abstract, in which you will see in advance the plan of the whole work.

The occasion of these experiments is as follows:

It is about four years since an experiment was tried in Italy thus: a glass tube about four feet long, with one end open, the other hermetically sealed, being filled with quicksilver, then the opening closed with the finger or otherwise, and placed perpendicular to the horizon with the stopped opening downward, is plunged two or three fingerbreadths into some more quicksilver contained in a vessel filled half with quicksilver, half with water; if the opening be unstopped, remaining the while submerged in the quicksilver of the vessel, the quicksilver in the tube will descend partly, leaving in the upper part of the tube a space empty in appearance, the lower end of the same tube remaining full of the same quicksilver up to a certain height. And if the tube be raised a little, so that the opening, previously

Digitized by Google

dipped into the quicksilver of the vessel, leaves the quicksilver and comes into the region of the water, the quicksilver in the tube ascends with the water to the top of the tube, and the two liquids are mingled in the tube; but finally all the quicksilver falls, and the tube is altogether full of water.

This experiment having been reported from Rome to Rev. Fr. Mersenne, he announced it in France in the year 1644, not without exciting the admiration of all savants and amateurs. As by their reports it became famous everywhere, I learned of it from M. Petit, superintendent of fortifications, a man well versed in *belles lettres*, who had heard of it from Rev. Fr. Mersenne himself. At Rouen, therefore, we did together, this M. Petit and I, the same as had been done in Italy, and we found detail for detail what had been reported from that country, without then observing anything new.

Then, reflecting by myself on the consequences of that experiment, I confirmed myself in the idea wherein I had always been, that a vacuum was not a thing impossible in nature, and that she did not avoid it with as much horror as many have imagined.

What forced me to this idea was the slight foundation which I saw for the maxim so generally received, that nature does not suffer a vacuum; which is based upon experiments for the most part entirely false, although held entirely reliable; and of the rest, some are far removed from contributing anything to the proof, and show that nature abhors too great congestion, and not that it avoids a vacuum; and the most favorable prove nothing more than that nature has a horror of a vacuum, and not that it cannot suffer one.

To the weakness of this as a principle, I would add the observations which we daily make about the rarefaction and condensation of the air, which, as some have shown, can be condensed even to the thousandth part of the space formerly occupied by it, and expands even so strongly; which I considered as necessarily so, either because there is much empty space between its parts, or because there is penetration of dimensions. But since the world as a whole did not accept this as proof, I believed that this Italian experiment was capable of convincing even those most biased as to the impossibility of a vacuum.

Nevertheless, the force of prejudice always finds objections which take away deserved credit. Some say that the top of the tube is full of the vapors of mercury; others talk of an imper-

Digitized by Google

ceptible granulation of rarefied air; others, of a kind of matter which does not exist outside of their imagination; and all, conspiring to outlaw the vacuum, emulate one another in that faculty of the mind which they call subtlety in the schools, and which in the solution of real difficulties gives nothing but vain words without foundation. I therefore resolved to do experiments so convincing as to be proof against all possible objections; of such I made a great number at the beginning of this year, some of them related to the Italian experiment, others entirely unrelated and having nothing in common with it. They were so exact and so satisfactory that by their means I showed that a vessel as big as can be made can be rendered entirely empty of all the kinds of matter which fall under our senses, or which are known in nature; also what force is necessary for producing a vacuum. Moreover, I tested the height necessary for a siphon to produce the effect expected of it, above which limiting height it no longer acts, contrary to the opinion so universally held in the world through so many centuries; also the small force needed to draw the piston of a syringe, without any matter taking its place; and many other things which you will see in the complete work; wherein I design to show the force employed by nature to avoid a vacuum, and how she actually allows and suffers it in a large space, which is easily made empty of all forms of matter which fall under the senses. Hence I have divided the complete treatise into two parts, the first containing at length an account of all my experiments, with figures, and a recapitulation of what they mean, divided in several maxims; the second, the consequences which I have deduced from them, in several propositions, wherein I have shown that space apparently vacuous, as it appeared in the experiments, is in fact empty of all the forms of matter which fall under the senses or are known in nature. In the conclusion, I give my ideas on the subject of vacuum, and reply to possible objections. So, I content myself with demonstrating the existence of a large vacuum, and I leave it to savants and scientists to find out what happens in such a region; as, whether animals can live there; whether glass in it diminishes its refractive power; and everything one can do there; not mentioning this in the treatise, of which I have thought to give you this abstract in advance, since, having made these experiments at much expense and spent much trouble and time, I feared that somebody else who had not spent the time or the money or the pains, anticipating

Digitized by Google

me, might give to the public facts of which he was not a witness, and so which he could describe with the accuracy and the order necessary for proper deductions; no one having had tubes or siphons as long as mine, and few being willing to take the trouble to have them.

And since honorable people join to the general inclination of all men, to defend themselves in their just possessions, also that of refusing honor not due them, you will no doubt approve me likewise, defending myself against those who would wish to deprive me of any of the experiments which I here give you or promise you in the complete treatise, for they are my own invention; and against those who would attribute to me that Italian experiment just described, since it is not mine. Although I have done it in more ways than anyone else, with tubes of twelve and even fifteen feet long, nevertheless I will not speak of that alone in this, not being its inventor; as I have no design of giving what is not my own, the fruit of my own ingenuity.

Abstract of the First Part, Wherein Are Described the Experiments.

Experiments.

I. A glass syringe with a well-fitting piston is plunged entirely into water, and its opening is closed with the finger, so as to touch the piston at the bottom, for this purpose the hand and arm being put into the water; one has need of only a moderate force to withdraw the piston and separate it from the finger, without the water entering in any way, (something the philosophers have believed could not be done with any finite force); then the finger is felt to be strongly and painfully drawn in; the piston leaves a space empty in appearance, into which it does not seem that anything can have got, since it is completely surrounded with water that can have had no access, the opening being closed; if one draws the piston farther out, the space empty in appearance becomes greater, but the finger feels no greater suction; and if one removes the syringe almost entirely from the water, so that only the opening remains immersed with the finger closing it, then on removing the finger the water, contrary to its nature, rises with violence and entirely fills the space vacated by the piston.

II. A bellows thoroughly tight on all sides does the same thing with similar precautions taken, against the belief of the same philosophers.

Digitized by Google

III. A glass tube forty-six feet long, with one end open and the other hermetically sealed, filled with water, or better with red wine, for better visibility, is then stopped and in that condition raised and placed perpendicular to the horizon with the stopped open end down, immersed about a foot in a vessel full of water. If the opening is unstopped, the wine in the tube descends to a certain height, about thirty-two feet above the level of the water in the vessel, runs out and mixes with the water in the vessel, which it colors slightly, while it separates from the glass at the top, leaving a space about thirteen feet long, apparently empty, where it does not seem as if anything could have got in. If the tube be tipped, then the height of the wine in the tube decreases by the inclination, the wine ascends till it reaches the height of thirty-two feet; and if finally the tube be tipped just to the height of thirty-two feet, it is entirely filled, sucking in moreover the water which had been ejected by the wine; so that it is full of wine from the top to thirteen feet from the bottom, and full of water slightly tinted in the thirteen feet below.

IV. A siphon with unequal legs, the longer fifty feet, the shorter forty-five, is filled with water and the two openings stopped and placed in two vessels of water, each immersed about a foot, so that the siphon was perpendicular to the horizon, and the water surface in one vessel is about five feet higher than that in the other; if the two openings be unstopped with the siphon in this condition, the longer leg does not draw the water from the shorter, and consequently not from the vessel in which it is, contrary to the beliefs of all philosophers and artizans; but the water falls in the two legs standing in the two vessels, to just the same height as in the tube just described, reckoning the height from the surface of the water in each vessel; but after inclining the siphon below the height of about thirty-one feet, the longer leg draws the water from the vessel of the shorter one; and on raising it above this height, this stops, and both the two sides discharge, each into its own vessel; and on lowering, the water in the longer draws the water in the shorter, as before.

V. If into a fifteen-foot tube sealed above at one end and filled with water there be put a fifteen-foot cord with a thread attached to its end (this is to be inserted into the water slowly, so that it may take it up little by little—air might somehow be enclosed in it), so that there is nothing outside the tube

Digitized by Google

except the thread attached to the cord for drawing it out, and if the opening be immersed in quicksilver, when the cord is withdrawn little by little, the quicksilver rises proportionally, until the height of the quicksilver, added to the fourteenth part of the height of the remaining water, is two feet three inches; then, as the cord is pulled, the water leaves the top of the tube, and leaves a space empty in appearance, which continually increases as one keeps on pulling the cord. If the tube be inclined, the quicksilver of the vessel enters, so that, with sufficient inclination, the tube is entirely filled with quicksilver and water which strikes the top of the tube violently, making the same sort of noise or report as if the tube were broken; and, in fact, it does run a risk of breaking. To get rid of the little bit of air, which, so to speak, is lodged in the cord, one can do the same experiment with a number of little wooden cylinders, attached together with a brass wire.

VI. A syringe with a perfectly fitted piston is put into quicksilver so that its opening is immersed at least an inch and the rest of the syringe stands perpendicularly outside; if the piston be drawn, the syringe remaining as described, the quicksilver enters through the opening of the syringe, rises and remains in contact with the piston until this has gone up in the syringe two feet three inches; beyond this height, if the piston be drawn still farther, it does not draw the quicksilver any higher, but this leaves the piston and remains constant at this height of two feet three inches; so that there is made a space empty in appearance, which becomes greater in proportion as the piston is drawn further. It is probable that the same thing happens in a suction pump, and that the water rises in this only to the height of thirty-one feet, which corresponds to two feet three inches of quicksilver. More remarkable is this: that the syringe, if weighed in this condition, without removing it from the quicksilver or moving it in any way, has the same weight, although the space apparently empty be as small as desired, as when, withdrawing the piston farther, we make this space as large as we choose, and that it always weighs the same as the body of the syringe together with the quicksilver contained at the height of two feet three inches with not any apparently empty space—that is, when the piston has not yet left the quicksilver in the syringe, but is at the point of breaking away from it if pulled ever so little. So that the apparently empty space, although all the bodies about it tend

Digitized by Google

to fill it, causes no change in weight, and that, whatever be the differences in size among such spaces, there is none among the weights.

VII. A siphon, whose long arm is ten feet, short arm, nine and a half, is filled with quicksilver and its two openings put into two vessels of quicksilver, each immersed about an inch, so that the quicksilver surface in one is about a half-foot higher than that in the other. When the siphon is perpendicular, the long arm does not attract the quicksilver from the short; but the quicksilver, breaking at the top, descends in each arm and empties into the vessels, and falls to the usual height of two feet three inches, measured from the surface of the quicksilver in each vessel. If the siphon be inclined, the quicksilver mounts again from the vessels into the tubes, fills them and commences to flow from the short arm into the long, and so empties its vessel. For this inclination of the tubes, wherein is the apparent void, when they stand in any liquid, always draws the liquids from the vessels, if the openings of the tubes are not closed, or draws the finger, if it closes the openings.

VIII. The same siphon is completely filled with water, and then with a cord, as above, the openings being put into the same two vessels of quicksilver; when the cord is withdrawn by one of the openings, the quicksilver ascends from the vessels into both the two arms, so that the fourteenth part of the height of the water in one arm, together with the height of the quicksilver which has ascended in it, is equal to the fourteenth part of the height of the water in the other, together with the height of the quicksilver which has ascended in it. The result is that this fourteenth part of the height of the water, together with the height of the quicksilver in each arm, is a height of two feet three inches; for then the water divides above, and there is formed an apparently void space.

From these experiments, and many others reported in the complete book, wherein are seen tubes of all lengths, sizes and shapes, filled with different liquids, variously immersed in different liquids, carried from some into others, weighed in various fashions, and wherein are described the different attractions felt by the finger closing the tube with the apparent void, there are deduced readily these maxims:

Maxims.

I. That all bodies show a repugnance toward separation one from another, and to allowing an apparent void between

Digitized by Google

them, i. e., that nature abhors this apparent void.

II. That this horror or repugnance of all bodies is no greater toward allowing a large void than a little one; i. e., for separation by a large interval than by a small one.

III. That the force of this horror is limited, and equal to that with which water of a certain height, about thirty-one feet, tends to flow downward.

IV. That bodies which bound the apparent void have a tendency to fill it.

V. That this tendency is no stronger for filling a large void than for a little one.

VI. That the force of this tendency is limited, and always equal to that with which water of a certain height, about thirty-one feet, tends to flow downward.

VII. That a force greater, but as little greater as one chooses, than that with which water of a height of thirty-one feet tends to flow down, is enough to cause the sufferance of this apparent void, even as large as one may wish; i. e., to cause bodies to be disunited by an interval as great as one may choose, provided that there is no other obstacle to their separation or displacement except the horror which nature has for the apparent void.

(There then follow eight propositions denying the existence of a plenum of various imagined sorts, and asserting that the "space void in appearance" of the preceding actually contains no known kind of matter, real or hypothetical, including vapors of liquids; then an abstract of the conclusion expressing this opinion, thus:)

Having demonstrated that no sort of matter falling under our senses, and of which we have knowledge, fills this space void in appearance, until somebody shall have shown the existence of some kind of matter filling it, my opinion will be that it is really empty, and destitute of all matter.

Wherefore I shall call that a real vacuum, which I have shown as an apparent vacuum, and I will hold for true the maxims given above, and enounce them for the absolute vacuum as I have for the apparent, thus:

(Here follow the maxims above, but with the word "apparent" omitted from connection with "void" or "vacuum." And, finally, the statement of and reply to certain objections.)

Digitized by Google

Objections.

I. That the proposition that there is empty space is repugnant to common sense.

II. That the proposition, nature abhors a vacuum, and nevertheless allows it, accuses nature of impotence, which implies a contradiction.

III. That numerous experiences, even everyday, show that nature cannot suffer a vacuum.

IV. That an imperceptible matter, unheard of and unknown, to all the senses, fills such a space.

V. That light being either an accident or a substance it is not possible for it to exist in a vacuum, being an accident; and it fills that space void in appearance, being a substance.

A GEOMETRIC RECREATION.

By Isabel Harris,

Richmond, Va.

In the Collegiate School for Girls of Richmond, Virginia, a class in plane geometry, consisting of twenty girls, bubbling over with an unusually effervescent enthusiasm, planned this unique and fascinating modification of the usual contest in geometry.

The members of the class got together and divided themselves into two groups and each group selected in an animated voting contest one of their number to be captain. These two captains with the instructor were asked to form a committee to draw up the regulations that should govern the contest, and the following resolutions were submitted to the class:

I. There shall be a series of six contests in Math. IV during the months of December, January, February, and March.

II. The class shall be divided into two teams, consisting of a captain and nine members. The names of the teams shall be the Pythagoreans and the Platonians.

III. The instructor in mathematics shall referee the contest.

IV. Each team shall elect an official score keeper.

V. The propositions to be proved shall be selected by the referee and shall be written on the board one at a time.

VI. The first trial of the first proposition shall be decided by lot and shall thereafter alternate with the two teams.

VII. When a proposition is given by the referee, the captain shall appoint a member of her team to attack it. If she gives a logical proof, that side scores two points. If she fails to give

Digitized by Google

a proof, the captain can call on another member of the same team. If she proves the proposition, the team scores one point. If she fails to prove it, the opportunity of proving the proposition goes to the opposing team. The opposing team proving it scores one.

VIII. When a member of one team fails to give a correct proof, that member is disqualified for the day.

IX. A member having proved a proposition is not entitled to another trial until all other members have been given an opportunity to attack a proposition.

X. An illogical proof detected by the opposing team at end of proof shall score one-half point for that team.

XI. Any interruption of the one proving a proposition, either by her own team or the opposing team before she has reached the Q. E. D., shall be considered an "error" and shall score one-half point for the opposing side.

XII. At the close of the contest the team having the highest score shall be guests of honor at a "feast" given by the losing team.

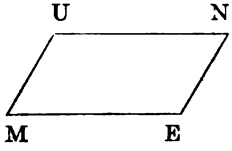
.....Captain of Platonians.
.....Captain of Pythagoreans.
.....Referee.

The regulations were received with a suppressed and tense enthusiasm, and were adopted by a unanimous vote. The contests followed in rapid succession and the interest was kept up by a careful selection of original exercises, beginning with simple propositions and continuing by easy ascents to more difficult ones. The teams were well matched and the competition was spirited. First one team and then the other was ahead, and the whole school watched with increasingly eager interest the outcome of each contest. Intercollegiate basket ball games and the World Series in baseball were no more discussed and rose to no higher point in the scale of school interests than the score of the Pythagoreans and the Platonians.

The Pythagoreans were the final victors and the Platonians evolved this clever scheme of giving them a mathematical "feast." Mystic invitations written on paper oiled with Wesson oil to represent parchment and rolled like scrolls, bade the guests to the party. They were greeted at the door by Plato's ominous motto printed in big, bold letters: "Let no one ignorant of geometry enter here." Guests and hostesses were all seated at one long table, which was elaborately decorated with vases

Digitized by Google

of "flowers" made by tying various mathematical symbols cut out of pink crepe paper to small bushy branches of shrubs. Over the table were scattered other symbols and the candle shades were decorated with weird and fantastic mathematical expressions. On the place cards were drawn familiar geometric figures. The following menu was served. Since the reader can not have the opportunity of verifying the menu by the courses served, an interpretation is given below.)



Given:

Proper Fractions
(Lettuce)$^{-1}$

Quadrilaterals Triangles

Extracted Roots

Homogeneous Cream@ +32°F
+Cake made by Heron's Formula
Cylinders with ‖ Lines.
Champagne (Imaginary)
H_2O (Real)

To prove that the Pythagoreans are equal to any occasion.
(Hint. Prove by elimination of hypothesis.)
Time Limit ∞

Interpretation
Given:

Chicken salad over lettuce

Saltines Sandwiches

Saratoga chips

Ice cream
and cake
Society mints

Mr. Evershed thinks that the values of the color indices assigned by Prof. N. H. Russell to the sun and Venus (+ .79 m. and + .78 m.) are mutually inconsistent, since they imply that no selective absorption takes place in Venus's atmosphere. Mr. Evershed finds evidence of decided selective absorption in the violet, as compared with his cloud spectra.— *Nature* (London), Feb. 19, 1920, p. 675.

U. S. GEOLOGICAL SURVEY ESTABLISHES RESIDENT GEOLOGIST IN SAN FRANCISCO BRANCH OFFICE.

J. M. Hill of the United States Geological Survey, has been transferred from Washington to the Survey's office in San Francisco where he will be associated with Charles G. Yale. Mr. Hill's field of geological studies will include the Pacific Coast States and to some extent also Arizona and Nevada. The desirability of having a geologist attached to the San Francisco office has long been felt, for many requests for examination and report are received that can not be met by sending a Federal geologist across the continent.

Digitized by Google

THE GRAPHICAL SOLUTION OF SPHERICAL TRIANGLES.

By Myron O. Tripp,
University of Maine, Orono, Me.

It is quite common to teach plane trigonometry in such a way that the graphical solution of plane triangles parallels the computational solution carried out by means of tables. The object of this article is to show that the same parallelism may be performed in the spherical trigonometry, that is, all spherical triangles may be represented in such a way that the remaining parts in the solution may be determined graphically. We may, therefore, check computational solutions in spherical trigonometry on the drawing board. An especial advantage of solving spherical triangles by drawing plane figures is that the student gets much drill in connecting spherical geometry with spherical trigonometry, and thus obtains a clearer understanding of both subjects.

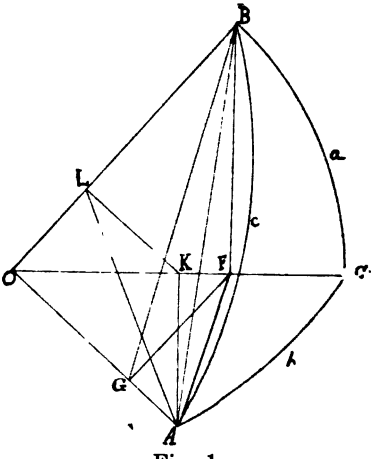


Fig. 1

For the greater part, the proposed graphical solution amounts to a correlation of spherical trigonometry and descriptive geometry. In some of the cases, however, it has been thought best to depart from the methods of descriptive geometry. The descriptive geometry involved in what follows is so simple that it is hoped that everything may be understood without assuming a previous knowledge of that subject.

Case I. Given two sides a and b of a right spherical triangle, to determine graphically the remaining parts.

In Fig. 1 the triangle is drawn in perspective. Let us call the plane through O (the centre of the sphere), B and C, that is, the plane through the side a, the vertical plane, or, in short,

Digitized by Google

the V-plane; and the plane through b the horizontal, or H-plane. Imagine now the H- and V-planes hinged about OC, and the H-plane turned through 90° downward, into the V-plane. Fig. 1 becomes Fig. 1 (a), the two figures being related in such a way that to the unprimed letters in the former correspond primed letters in the latter; or we may turn the V-plane 90° backward into the H-plane, likewise making Fig. 1 pass over into Fig. 1 (a).

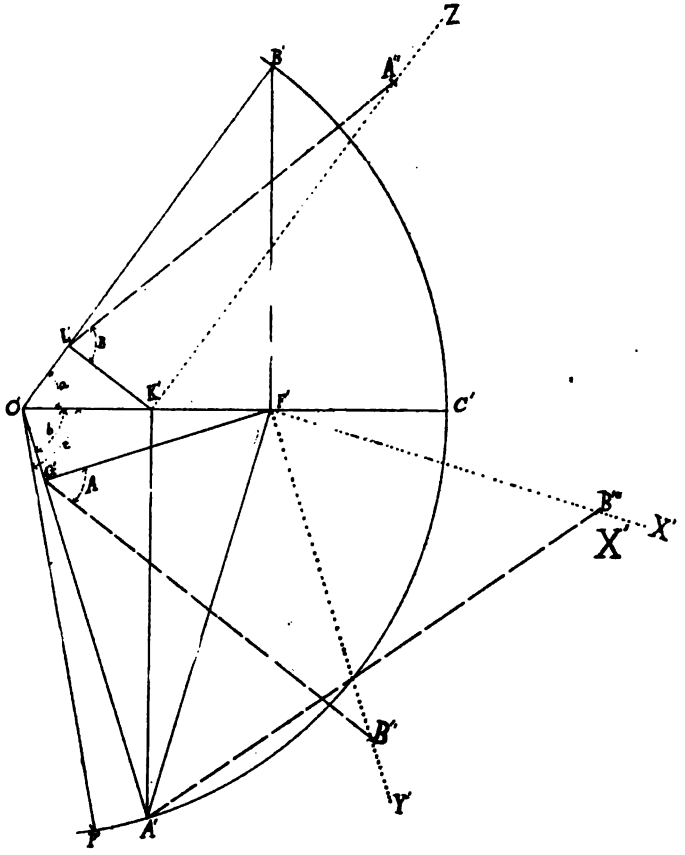


Fig. 1 (a)

In Fig. 1, BF is perpendicular to OC and FG is perpendicular to OA. Hence, $\angle BGF = \angle A$

Similarly $\angle ALK = \angle B$,

AK and KL being perpendicular to OC and OB respectively.

The graphical solution is now carried out as follows: On O'C',

Digitized by Google

and above it, construct at O′ an angle equal to a. Likewise, below O′C′ construct an angle equal to b at O′. From B′ drop a perpendicular B′F′ on O′C′, and from F′ a perpendicular on O′A′ meeting it in G′. We next revolve GFB about GF into the H-plane. This is accomplished by drawing at F′, F′Y′ perpendicular to F′G′, and laying on F′Y′ the distance F′B″ = F′B′. Thus the triangle GFB, when laid down in the H-plane, becomes G′F′B″. Hence,

$$\angle FGB = \angle F'G'B'' = \angle A.$$

To determine the angle B we turn the triangle ALK about LK into the V-plane, that is, we drop from A′ a perpendicular A′K′ upon O′C′; and then from K′ drop a perpendicular K′L′ upon O′B′ from K′. At K′ draw the line K′Z′ perpendicular to L′K′, and on it lay off K′A″ = K′A′.

Hence we have

$$\angle K'L'A'' = \angle KLA = \angle B.$$

To determine the hypotenuse c we revolve the triangle AFB about AF into the H-plane, that is, we draw F′X′ perpendicular to A′F′, and on it lay off F′B‴ = F′B′. A′B‴ is now the true length of AB. With C′ as a centre, and radius equal to A′B‴, strike an arc cutting C′A′ produced at P′. We then have

$$\angle P'O'C' = c.$$

Case II. Given a and c, that is, the hypotenuse and one side, to find the remaining parts.

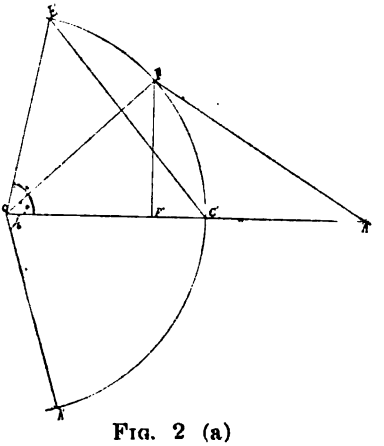


FIG. 2 (a)

We start with Fig. 1 and pass from that to Fig. 2 (a) just as we passed from Fig. 1 to Fig. 1 (a) in Case I. On O′C′ construct an angle C′O′B′ equal to a, and C′O′E′ equal to c. Thus the line C′E′ is the true length of AB. Using C′E′ as a hypotenuse

Digitized by Google

and B′F′ as one side construct the plane right triangle F′B′A″, that is, we have B′A″ = E′C′. Hence F′A″ is the true length of FA. With F′ as a centre, and radius equal to F′A″, cut the arc B′C′ produced in A′. Therefore the distance from F′ to A′ equals FA.

Hence,

$$\angle A'O'C' = b.$$

The remaining parts may be found as in case I, since we now know two sides

Case III. Given a and A in a right spherical triangle, that is, a side and the angle opposite, to find the remaining parts.

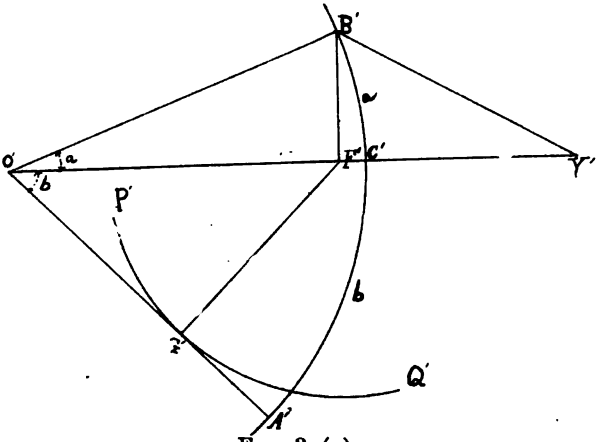


FIG. 3 (a)

Let us use Fig. 3 (a) and Fig. 1 as in the previous cases. Construct the angle C′O′B′ equal to a. From B′ drop a perpendicular B′F′ on O′C′. With the angle A and side B′F′ construct the plane right triangle B′F′Y′, that is, we make

$$\angle F'B'Y' = 90^\circ - \angle A.$$

With F′ as a centre, and radius equal to F′Y′, describe the arc P′Q′; and then from O′ draw O′A′ tangent to the arc P′Q′. Hence we have

$$\angle A'O'C' = b.$$

This operation amounts to constructing the triangle FGB in the V-plane and then rotating the triangle about F′B′, so that Y′ describes the arc of a circle in the H-plane, and then stopping the triangle in the position of FGB as shown in Fig. 1.

Since we have found b, the remaining parts may be found as in Case I.

Case IV. Given the side a and the adjacent angle B in a right spherical triangle, to construct the remaining parts.

Digitized by Google

Figures 4 and 4 (a) are related to one another just as 1 and 1(a)

In the V-plane construct the angle C'O'B' equal to a. At L' any point on O'B', draw in the plane a perpendicular to O'B'

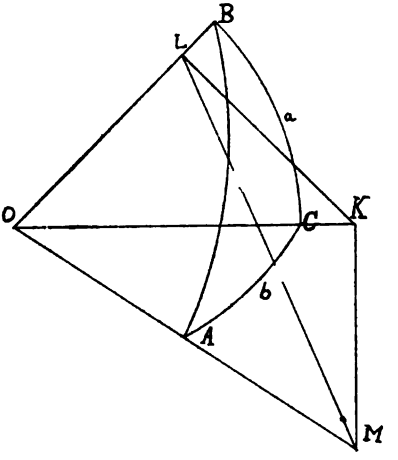


FIG. 4

cutting the intersection of the H and V planes in K'. With L'K' as a side and angle B as an adjacent angle construct the plane right triangle L'K'M''. From K' draw, in the H-plane, a perpendicular to O'K' and lay off on it K'M' equal to K'M''. Connect M' and O'. Then

$$\angle M'O'K' = b.$$

Having now two sides a and b we can proceed just as in Case I to find the remaining parts.

Case V. Given the hypotenuse c and the angle A adjacent to it, to construct the remaining parts.

In Fig. 5(a) lay off the angle B'O'A' equal to c. At A' draw a tangent to the arc B'A', and produce O'B' until it cuts this tangent in T'. Using A'T' as the hypotenuse of a plane triangle and the angle A as one of the acute angles, construct the right triangle A'Q'T'. In Fig. 5 this triangle is shown in perspective as AQT. TA and QA being perpendicular to OA, $\angle TAQ = \angle A$.

We next construct a right triangle with the two sides A'Q' and A'O'' (= A'O'). This triangle is shown in Fig. 5 as OAQ. Hence

$$\angle A'O''Q' = b.$$

The remaining parts may be found by Case II or case IV. However, a convenient way of finding a is as follows:

Digitized by Google

Let us construct a plane right triangle with O″Q′ and Q′T″ (= Q′T′) as sides. This triangle is shown in Fig. 5 as OQT. Hence,

$$\angle Q'O''T'' = a.$$

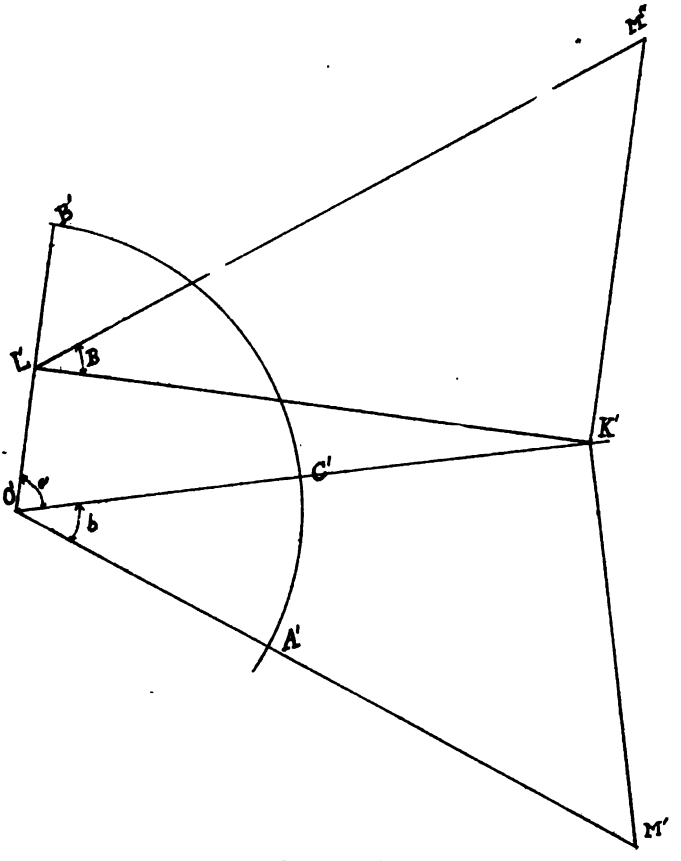


FIG. 4 (a)

Case VI. Given two angles A and B of a right spherical triangle to construct the remaining parts.

In Fig. 6 the triangle $A_1B_1C_1$, drawn in perspective, is the polar of the triangle ABC, the latter triangle not being shown.

Produce A_1B_1 and A_1C_1 to meet in G, thus forming another triangle B_1C_1G. Draw tangents to the arcs C_1B_1 and C_1G at C_1 and produce them to meet OB_1 and OG produced in D and E respectively. Then the angle DC_1E is supplementary to the angle $B_1C_1A_1$, and hence,

$$\angle DC_1E = c.$$

By means of the triangle DC_1E we propose to construct an angle equal to c. In Fig. 6(a) lay off a distance $O'C_1'$, = OC_1,

Digitized by Google

and at O′ lay off a_1 and b_1', a_1 being equal to $(180 - \angle A)$ and b_1' being equal to $(180 - b_1)$ $(= \angle B)$.

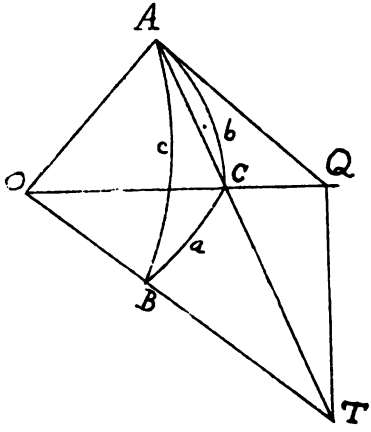


FIG. 5

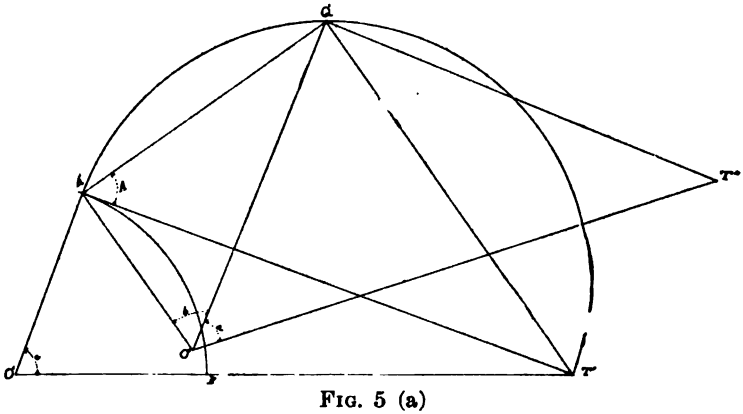


FIG. 5 (a)

To the triangle OC_1D of Fig. 6 corresponds the triangle $O'C_1'D'$ of Fig. 6(a); while to OC_1E corresponds $O'C_1'E'$. We have thus found as the true lengths of C_1D, OD, C_1E and OE the segments $C_1'D'$, $O'D'$, $C_1'E'$ and $O'E'$ respectively.

With $O'D'$ and $O'E'$ and the included angle of 90° we construct the triangle $O'E''D''$; thus $D''E''$ is the true length of DE. If now we construct a plane triangle with the sides $D''E''$, $C_1'D'$, and $C_1'E'$, viz. $D''E''C_1''$ we have

$$\angle D''C_1''E'' = c.$$

Knowing c and A we can proceed as in Case V to find the remaining parts.

Oblique triangles. When three angles are given we may pass

Digitized by Google

over to polar triangle just as in case VI for right triangles, and solve exactly as in that case. If three sides are given we may solve without using the polar triangle.

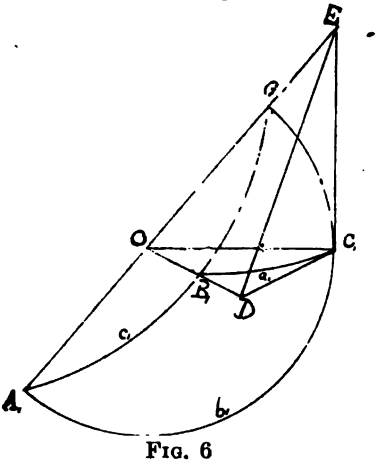


FIG. 6

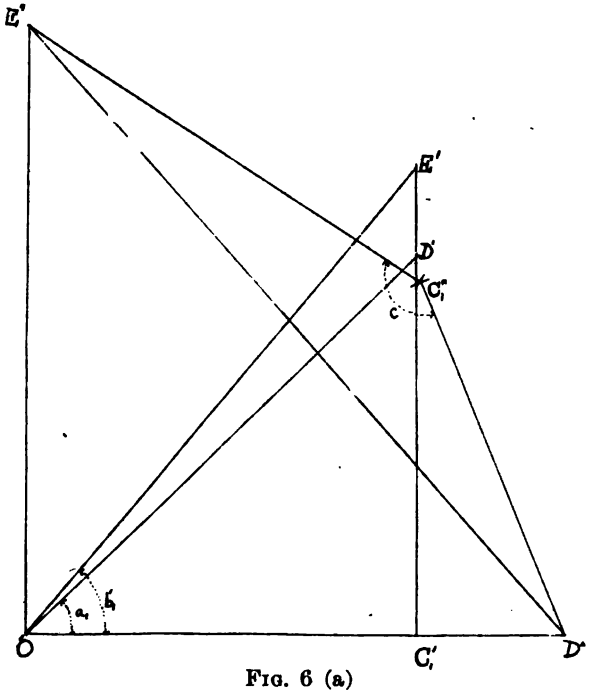


FIG. 6 (a)

When two sides, b and c, and the included angle, A, are given we solve by dropping a perpendicular arc from C upon AB as in Fig. 7 thus dividing the given triangle into two right triangles.

Digitized by Google

From b and A we can find all the parts of the triangle ACD. Then using CD and DB in the triangle DCB we can find all the parts of CDB. From the parts of the triangles ACD and BCD we easily determine the parts of the triangle ABC. By using the polar triangle the case in which a side and two adjacent angles are given is easily solved in the same way.

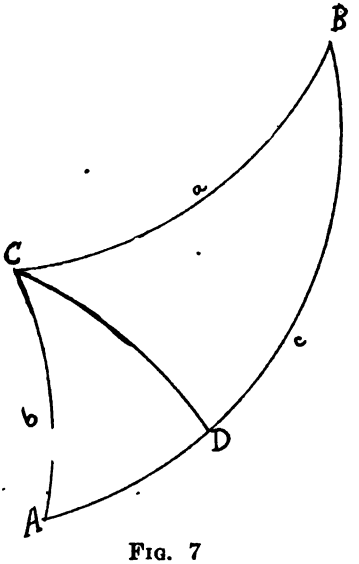


FIG. 7

When two sides and the angle opposite one of them are given e. g., a, b, and A, we can solve by right triangles (see Fig. 7) just as in the preceding case. Also the case of the two angles and the side opposite one of them can be solved by going over to the polar triangle.

ASBESTOS CAN BE FINE SPUN.

The earliest use of asbestos was for spinning and weaving, to make incombustible thread and yarn rope and cloth, and this has continued to be the most important use of asbestos ever since the days of the Greeks and Romans. Only the best grades can be used for this purpose, according to J. S. Diller, of the United States Geological Survey, Department of the Interior. Thread can now be spun so fine that it will run about 32,000 feet to the pound.

MAP OF COAL FIELDS OF THE UNITED STATES.

The United States Geological Survey, Department of the Interior, is now distributing a large map showing the coal fields of the United States. This map, which measures 4½ by 7 feet, shows the coal fields by a s ries of colors indicating the seven different kinds or grades of coal as it is classified by the Geological Survey—anthracite, semibituminous, high-grade bituminous, low-grade bituminous, lignite, and coking coal. The map is sold by the Geological Survey for $1, or for 60 cents each if five or more maps are ordered together. Besides the coal fields this map shows all the cities, railroads, lakes, and other features that are found on a map of this size.

Digitized by Google

PROBLEM DEPARTMENT.

Conducted by J. A. Nyberg,

Hyde Park High School, Chicago.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. If you have any suggestion to make, mail it to him. Address all communications to J. A. Nyberg, 1044 E. Marquette Road, Chicago.

SOLUTION OF PROBLEMS.

656. *Proposed by F. A. Cadwell, St. Paul, Minn.*

ABC is an isosceles triangle, AB = AC; and AE is a line not cutting the sides of the triangle. A point D on AE is chosen so that BD = BC and $\angle ADB = 150°$. Prove $\angle DAB$ is one-third of $\angle DAC$.

I. *Solution by Louis Sklav, Student at the Drexel Institute, Philadelphia.*

$AB/\sin 150° = BD/\sin BAD$. But since $\sin 150° = 1/2$,

$\sin BAD = BD/2AB = BC/2AB$.

Also, $\sin(BAC/2) = (BC/2)/AB = BC/2AB$.

Then, $\angle BAC = 2\angle BAD$ or $\angle BAD = \angle CAD/3$.

II. *Solution by J. H. Packham, Owen Sound, Canada.*

Draw $AF \perp BC$, and $BE \perp AE$. AF bisects BC and $\angle BAC$. $\triangle EDB$ has angles 30°, 60°, 90°. Then EB = BD/2 = BF so that $\triangle$s BAE and BAF are congruent. Hence $\angle EAB = \angle EAC/3$.

Also solved by N. Barotz, New York City; A. Pelletier, Montreal, Can., and W. R. Warne, State College, Pa. (3).

657. *Proposed by Walter R. Warne, Pennsylvania State College.*

If $x^2 = a^2+b^2$, $y^2 = c^2+d^2$, show that $xy > (ac+bd)$.

Solution by A. Pelletier, Ecole Polytechnique, Montreal, Can.

We have successively,

$$(ad-bc)^2 > 0, \text{ if } ad \neq bc,$$
$$a^2d^2+b^2c^2 > 2abcd,$$
$$a^2c^2+b^2d^2+a^2d^2+b^2c^2 > a^2c^2+b^2d^2+2abcd,$$
$$(a^2+b^2)(c^2+d^2) > (ac+bd)^2,$$
$$x^2y^2 > (ac+bd)^2,$$
$$|xy| > |ac+bd|.$$

Also solved by N. Anning, Ann Arbor, Mich. It should be noted that the solution is not really complete unless mention is made that $ad \neq bc$, (try $a = 3$, $b = 4$, $x = 5$, $c = 6$, $d = 8$, $y = 10$), and that absolute values must be considered in the final equation. Even when omitted in the statement of a problem, no mathematician should be satisfied with his solution until all the possibilities have been considered.

658. *Proposed by the Editor.*

Given two points A and B. Find, using only dividers, two points C and D so that ABCD will be the corners of a square.

I. *Solution by F. A. Cadwell, St. Paul, Minn.*

With A as a center and AB as radius, describe a circle O. With B as a center and AB as a radius, describe a circle O′, intersecting O at E and F.

With E as center and EF as radius, describe arcs intersecting O at H and O′ at G.

With A as center and EF as radius, describe arc JK. With B as center and EF as radius, describe an arc intersecting JK at I.

With G as center and GI as radius, describe an arc intersecting the circle O at D.

With H as center and HI as radius, describe an arc intersecting the circle O′ at C.

Two other points C′ and D′ opposite C and D can similarly be found for a second solution.

Digitized by Google

Proof: (As the proof is rather long, the editor has cut out all except the main facts.) Regard AB as a unit length, and let L be its midpoint. Then $EF = \sqrt{3} = EG = EH$, so that H, A, B, G lie on a line and are a unit apart.

In $\triangle LIG$, $LI^2 = BI^2 - LB^2 = EF^2 - LB^2 = 3 - 1/4 = 11/4$.

And, $GI^2 = LI^2 + LG^2 = 11/4 + 9/4 = 5$.

In $\triangle ADG$, $AD^2 = DG^2 - AG^2 = GI^2 - AG^2 = 5 - 4 = 1$.

II. *Solution by James Clarke, Junior at San Jose (Cal.) High School.*

With A and B as centers and AB as radius, draw two circles intersecting at G, and by the usual arcs find E diametrically opposite B, and F opposite A.

Using E and F as centers and EB as radius, draw arcs intersecting at O.

Using A as a center and AO as radius, draw an arc intersecting AGF at C; and with B as a center and BO as radius, another arc intersecting EGB at D.

C and D are the required points.

Proof (abbreviated by the editor): Regard AB as a unit, and let H be its midpoint. Then $EO = EB = 2$. $EH = 3/2$, and in $\triangle EOH$, $OH = \sqrt{7}/2$. And in $\triangle AOH$, $AH = 1/2$, $OH = \sqrt{7}/2$ so that $AO = \sqrt{2}$ and hence AO can be used as a diagonal for the square. (The proof that the triangles are right triangles has again been omitted by the editor. The symmetry of the constructions also proves that the resulting figure could not be a rhombus.)

III. *Solution by A. Pelletier, Montreal, Can.*

With radius AB and centers A and B, describe two arcs intersecting at E; with the same radius and center E, describe an arc cutting AE at G and BE at F; with radius FB and centers F and G describe two arcs intersecting at H. Finally, with radius EH, and centers A and B, describe arcs cutting AEG at C, and BEF at D, the required points.

Proof: $FE = AB$; $FH = FB = AB\sqrt{3}$. Hence in the right $\triangle FEH$, $EH = AB\sqrt{2}$. Therefore, $AB^2 + BC^2 = EH^2 = AC^2$ and so $\angle ABC = 90°$.

IV. *Comment by the Editor;*

The first solution depends on the finding of a line whose length is $\sqrt{11}$, then $\sqrt{9}$, then $\sqrt{5}$, using the last as a diagonal. The second solution finds $\sqrt{7}$, then $\sqrt{2}$; and the last one depends on $\sqrt{3}$, then $\sqrt{2}$. The first requires 8 arcs, the second 10, the third 8. Another method for finding $\sqrt{2}$ is the following: Draw circles with A and B as centers and AB as radius; call E and F their intersection points, and G the point diametrically opposite A. Then with A and C as centers and EF as radius, draw two arcs intersecting at H. $BH = \sqrt{2}$.

The writer knows only of one method which does not involve finding a diagonal, but it requires 26 arcs resulting in an inaccurate figure. If A and B are the given points, we can find points E, F, G, H on a line with AB and at unit intervals. If they are drawn to the right of B, then $AF = 3$, $AG = 4$, $AH = 5$. With F as a center and 5 for a radius draw an arc; with A as a center and 4 for a radius, draw an arc intersecting the previous one at I. With G as a center and 5 for a radius draw an arc; with A as a center and 3 for a radius draw an arc locating the point J. Then the points I and J are a unit apart and on a perpendicular to AB. The point diametrically opposite I on the unit circle with center J is the desired point D. Instead of numbers 3, 4, 5 we could use 5, 12, 13 but the points corresponding to I and J would be 7 units apart, necessitating further work.

659. *Suggested by H. C. Whitaker's comment on problem 645.*

Prove geometrically that if $R = 2r$, the triangle is equilateral.

I. *Solution by H. C. Whitaker.*

The distance d between the centers of the circumscribed and the inscribed circles is $d^2 = R^2 - 2Rr$. Hence when $R = 2r$, the circles are concentric, and the half angle of the triangle is 30° making the triangle equilateral.

II. *Solution by W. R. Warne.*

It is known that $R = abc/4\triangle$, and $v = \triangle/s$. If $R = 2r$, then $abcs = 8\triangle^2$ and the triangle is equilateral by problem 645.

Digitized by Google

Also solved by J. H. Packham, A. Pelletier. Several of the solutions received assumed that the two circles would be concentric. Again, neither of the two solutions above are strictly geometric; a geometric proof would involve a proof of Euler's relation $d^2 = R^2 - 2Rr$, a question which was raised some time ago in problem 415.

30. *Proposed by Martha G. Lathrop, Emmett, Idaho.*

Given three unequal non-intersecting circles O, O', O''. Let A be the intersection point of the common external tangents of O and O', B the point for O' and O'', C the point for O'' and O. Prove A, B, and C are collinear.

I. *Solution by Thomas E. N. Eaton, Redlands (Cal.) High School.*

If r, r', r'' are the respective radii, we have

$AO/AO' = r/r'$ $\quad BO'/BO'' = r'/r''$ $\quad CO''/CO = r''r$.

Then $AO \cdot BO' \cdot CO''/AO' \cdot BO'' \cdot CO = rr'r''/r'r''r = 1$. Hence by Menelaus's Theorem, ABC are in a straight line.

Similarly solved by J. H. Packham and A. Pelletier (3). The third solution by Pelletier is interesting;

II. Let us consider the circles OO'O'' as great circles of spheres; then the two tangent planes inclosing the spheres contain the points A, B, C; since these points are on the intersection of the two planes which is a line.

III. As the Theorem of Menelaus is found in few elementary geometries, its statement and proof is given here:

Every straight line (ABC) cutting the sides of a triangle (OO'O''), produced if necessary, determines upon the sides six segments such that the product of three non-consecutive segments equals the product of the other three.

Draw O''D parallel to OO', D being on ABC. From the similar triangles we get

$AO/DO'' = CO/CO''$ and $BO'/BO'' = AO'/DO''$.

Multiplication of these two equations gives the desired result.

To prove the converse let AB produced cut OO'' in a point E; then prove OE = OC.

PROBLEMS FOR SOLUTION.

. *Proposed by Emma H. Carroll, Phila. High School for Girls.*

Without the use of trigonometric relations prove: the distance on a side of a triangle from a vertex to the point of tangency of the inscribed circle equals one-half the perimeter minus the side opposite the vertex.

. *Dissection Problem proposed by Norman Anning, Ann Arbor, Mich.*

An equilateral triangle AFG is described outward on the side AF of regular hexagon ABCDEF. It is required to cut the figure so formed into three parts that will make an equilateral triangle.

. *Proposed by the Editor.*

The following problem is a "Sam Lloyd" puzzle taken from a Chicago newspaper. Its wording could be improved as it does not state who the oldest but the solution will reveal it. Although the paper said that no correct solution was received, algebra will help to solve it.

A father settled an annuity upon his three children, the same to be divided each year in the same proportion as their ages. At the first division the oldest was entitled to one-half of the entire amount. When the sixth payment was due, Martha received one dollar less than she got the first year, Phoebe one-seventh less than she first got, while John's share was twice as much as he received the first year. What is the amount of the annuity?

. *Proposed by Herbert C. Whitaker, Philadelphia, Pa.*

From a cask of wine holding 10 gallons, a dishonest servant draws off a gallon each day for 20 days filling the cask each time with water. But fearing detection, he again draws off a gallon each day for 20 days, filling the cask each time with wine. How much water remained?

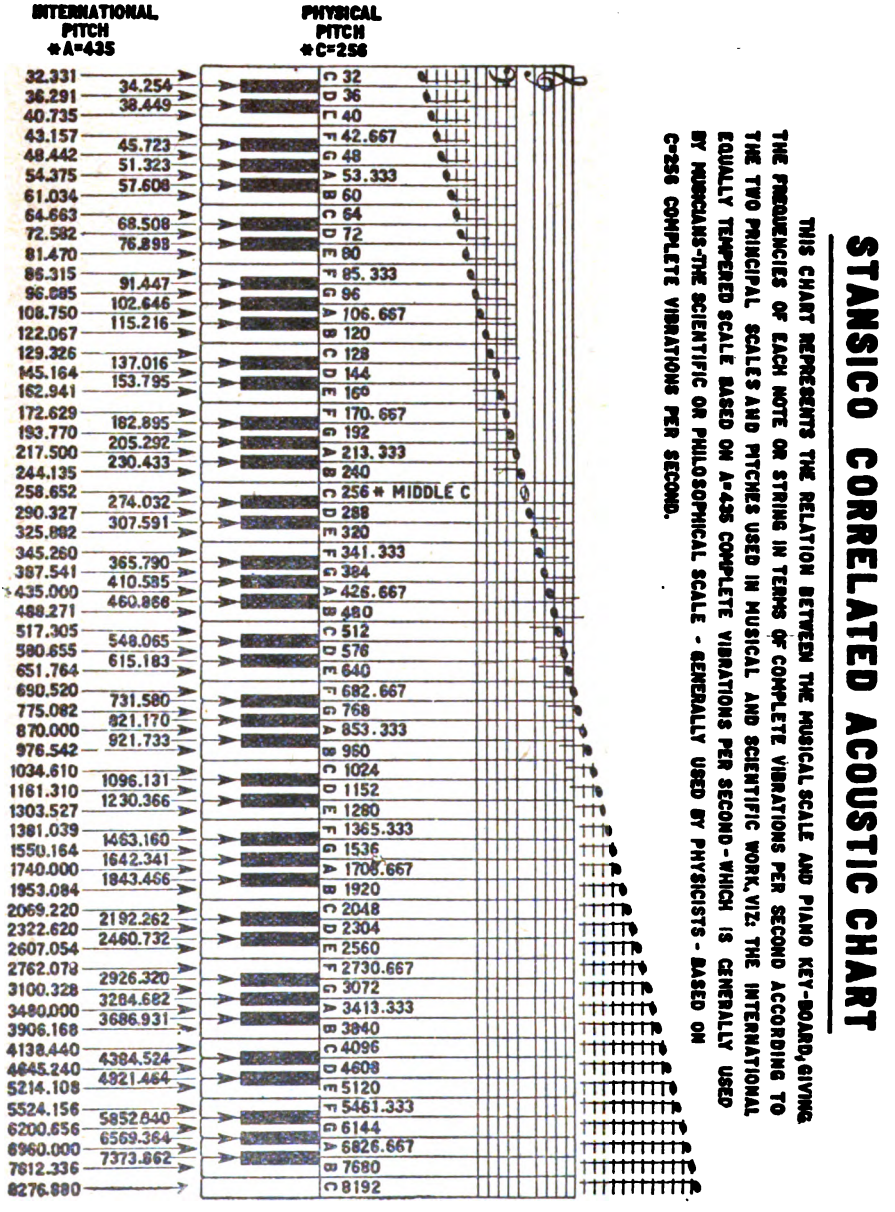
For Undergraduates. See announcement in October issue.

Proposed by Norman Anning, Ann Arbor, Mich.

G is the obtuse angle of a triangle whose sides are 7, 15, 20. H is the obtuse angle of a triangle whose sides are 5, 5, 8. Prove that

$$2G + H = 360°.$$

Digitized by Google



"A sample copy of the above chart will be sent without charge by addressing the Standard Scientific Company, 147 Waverly place, New York."

Digitized by Google

INDUSTRIAL ART SCHOOLS.

Establishment of industrial art schools in the United States, to meet the demand for designers and craftsmen, is urged by the American Institute of Architects.

Over half a million dollars is on deposit in one of the San Francisco banks to the credit of 20,788 school children. These school savings are in addition to large investments by the children in thrift stamps and war savings stamps.

Approximately 20 per cent of all children in the schools are in need of corrective treatment for eye defects, according to a bulletin on "The Eyesight of School Children," soon to be issued by the U. S. Bureau of Education.

A one story school building with as many as 48 rooms in a well-populated city and suburban section is possible under a plan adopted in Cuyahoga County, Ohio. This county now has four large school buildings of the one-story type, with from 5 to 10 acres of ground for each building.

More than a thousand men and women of foreign birth were enrolled in the Scranton, Pa., public evening and afternoon schools for non-English speaking men and women during the past year. Twenty-two nationalities were represented in the citizenship graduating class of 132 persons recently, according to reports received by the U. S. Bureau of Education.

"Sea gardening" is a feature of the school garden work among the Moros, in the Sulu group of the Philippine Islands, according to a report of the Commissioner of Education. Because the islands inhabited by these people, sea rovers for centuries, offered few facilities for cultivation of the ordinary crops, the schools established "sea gardens" in which attention is given to the culture of marketable. sea products, especially certain kinds of sponges.

CLASSROOM SAYINGS.

Question: Tell how the mercury thermometer is made, and compare the centigrade scale with the Fahrenheit scale.

Answer: They put it in a real hot boiler and seal it. Then they put in a real cold place and freeze it. Ice is good. Then they let it stand for five years, and after this they put a scale on it. Fahrenheit is a smaller scale than the centigrade.

A Fundamental tone is a tone produced when the string does not vibrate.

A virtual image is one that cannot be seen in the dark. A real image can.

Refraction of light is inversely proportional to the perpendicular.

From General Science Pupils.

A draft may be caused in a chimney sometimes because the chimney is too short and sometimes the wind may be blowing directly on that chimney.

Cause of draft in a chimney—not enough air on the inside to withstand that on the outside.

Relative humidity means moisture in the air in relation to the body.

The cold air of the draft gets into the pores of the skin and we catch cold.

A barometer is an instrument that measures the pressure of the atmosphere by degrees.

I would predict a frost when the dew freezes.

The words ampere, ohm, volt, watt, suggest to my mind a course in electricity.

Teachers: Send to the Editor samples of your very interesting answers.

Digitized by Google

DIMENSIONS AND AREA OF THE UNITED STATES.

The gross area of the United States is 3,026,789 square miles. The land area amounts to 2,973,774 square miles, and the water area—exclusive of the area in the Great Lakes, the Atlantic, the Pacific, and the Gulf of Mexico within the three-mile limit—amounts to 53,015 square miles. These and other data determined or compiled by the United States Geological Survey, Department of the Interior, to show the limits of the continental United States contain some interesting facts.

The southern most point of the mainland is Cape Sable, Fla., which is in latitude 25° 07′ and longitude 81° 05′. The extreme southern point of Texas is in latitude 25° 50′, and longitude 97° 24′. Cape Sable is therefore 49 miles farther south than the most southern point in Texas.

A small detached land area of northern Minnesota at longitude 95° 09′ extends northward to latitude 49° 23′.

The easternmost point of the United States is West Quoddy Head, near Eastport, Maine, in longitude 66° 57′ and latitude 44° 49′; the westernmost point is Cape Alva, Wash., in latitude 48° 10′, which extends into the Pacific Ocean to longitude 124° 45′.

From the southernmost point in Texas due north to the forty-ninth parallel, the boundary between the United States and Canada, the distance is 1,598 miles. From West Quoddy Head due west to the Pacific Ocean the distance is 2,807 miles. The shortest distance from the Atlantic to the Pacific across the United States is between points near Charleston, S. C., and San Diego, Calif., and is 2,152 miles.

The length of the Canadian boundary line from the Atlantic to the Pacific is 3,898 miles. The length of the Mexican boundary from the Gulf to the Pacific is 1,744 miles. The length of the Atlantic coast line is 5,560 miles and that of the Pacific coast line is 2,730 miles. The Gulf of Mexico borders the United States for 3,640 miles.

Nearly all maps of the United States show the parallels of latitude as curved lines and are likely to lead the ordinary observer to believe that certain eastern or western States are farther north than some of the central states that are actually in the same latitude. For this reason, one who is asked which extends farther south, Florida or Texas, is very likely to say "Texas," but, as stated, the mainland of Florida is nearly 50 miles farther south than the southernmost point in Texas. For the same reason, when we consider the geographic positions of countries south of the United States we find that errors are likely to be made in estimating position or extent in longitude. Few realize that the island of Cuba, for example, if transposed directly north would extend from New York City to Indiana, or that Havana is farther west than Cleveland, Ohio, or that the Panama Canal is due south of Pittsburgh, Pa., or that Nome, Alaska, is farther west than Hawaii.

ANIMAL WEATHER PROPHETS.

"Mere superstition," so the weather authorities say, are many of the long-distance weather predictions based on the conduct of animals. No one, so far as we know, has compiled a record of these so-called omens, but their number is multiple. They are based on a belief that animals are able to tell months in advance, for example, the character of the coming winter. If hunters bring a story to the effect that squirrels have made heavy stores of nuts, it is taken to mean that a severe winter impends. If early caught fur-bearing animals have a heavy, thick coat, that is another sign of a severe winter, or a thin coat, the contrary. If bird migrations are delayed after the usual date of the southward flight, a sign is seen of an open winter. Numerous other beliefs based on fancied ability of animals

Digitized by Google

to foresee weather conditions months ahead, and base their preparations on them, have wide currency. Sometimes signs are taken from the vegetable world, as for example, the past fall in the Middle West. Corn husks, it was related, were much heavier than usual—that meant a hard winter.

The reasoning, such as it is, in many of these weather signs, is apparent on the surface. In the case of others it isn't, as with the most famous and well-known of them all—the groundhog sign. If Mister Woodchuck on Candlemas day—February 2—sees his shadow, issuing experimentally from his den, then "winter will have another flight." Otherwise an early spring impends.

Observation over a part of a single lifetime would demonstrate most of these weather signs as unreliable, yet they cling on, especially in country districts. It is possible that they do so, in part, because they shadow into animal signs of a different class which really are dependable. From the conduct of animals, accurate weather predictions can, within certain limits, be made.

This dependable class of animal weather signs is uniformly short distance as to prophecy—no longer than the daily newspaper weather forecast. They occur because animals are more sensitive to atmospheric changes than human beings, and sense an approaching weather change hours before it is apparent to man. . . .

One animal barometer in this class, much observed east and west during the summer season, is the swallow. The swallow is insectivorous to the *-nth* degree. Other than insects hardly pass its bill from one season's end to another, and it captures this food on the wing. Thus it happens that as a weather forecaster the swallow on thousands of farms is always ready with an answer.

Swallows flying high indicate fair weather. Swallows flying low presage a storm. The explanation of these "signs" is simple. The relative level at which swallows fly is determined by the whereabouts of insects. The lighter the atmosphere, as in the case of fair weather or clearing weather, the higher will insects be found, while an oncoming storm, presaged by growing density, forces them to levels near the ground, where the swallows will be noticed in pursuit of them.—*Scientific American.*

PLANT PROTECTION INSTITUTE.

With the advice and assistance of the National Research Council, a cooperative body of scientific experts on injurious insects and plant diseases and of manufacturers of insecticides, fungicides and general chemicals and apparatus used in fighting the enemies of field and orchard crops, has just been organized under the name of the Plant Protection Institute. The purpose of the institute is to promote the general welfare by supporting and directing scientific research on the pests of crops, shade trees and ornamental plants, and on the methods of their control, and by furthering cooperation between the scientific investigators and the manufacturers of chemicals and appliances, especially for the sake of effecting standardization and economy in the production and use of the means of fighting pests. Also it expects to aid in the dissemination of scientifically correct information regarding the control of injurious insects and plant diseases.

Much excellent work along this line is now being done by government and state organizations, but a further advance can be made by introducing a wider coordination and cooperation of the efforts of both the scientific men and the manufacturers of control devices. It is in this general direction of cooperative work that the Plant Protection Institute expects to be most active.

Digitized by Google

INDUSTRIAL RESEARCH LABORATORIES IN AMERICA.

A bulletin just issued by the National Research Council lists more than three hundred laboratories maintained by industrial concerns in America, in which fundamental scientific research is carried on. The bulletin gives a brief account of the personnel, special equipment and particular kind of research carried on in each of the laboratories listed.

Industrial research laboratories have increased notably in number and activity, both in America and Great Britain, since the beginning of the war, because of the lesson vividly taught by the war emergency. It was only by a swift development of scientific processes that the Allies and America were able to put themselves in a position first to withstand and then to win a victory over Germany's science—backed armies and submarines. It is only by a similar and further development that America and the Allies can win over Germany in the economic war-after-the-war, now being silently but vigorously waged.

LAKE TAHOE HAS SHRUNKEN.

Lake Tahoe, in California, is often said to occupy an old volcanic crater. This is not a fact. It is true that the region about the lake shows evidence of volcanic activity of various kinds and that the water has at times probably been dammed by outpourings of lava, but the lake itself lies in a structural depression—a dropped block of the earth's crust.

The prehistoric Lake Tahoe was larger and deeper than the present lake according to the United States Geological Survey, Department of the Interior. During the Neocene epoch and the earlier part of the Pleistocene epoch its water stood much higher than now but in its overflow it has since cut through the lava dams that maintained it at that height. Distinct beaches that mark the former higher levels of the lake stand about 100 feet above its present surface but the water doubtless once stood at even greater heights. At Tahoe City the most distinct of these old beaches is a terrance that stands 35 to 40 feet above the level of the lake. It is on this ancient beach that Tahoe Tavern is built.

MAPS OF SUMMER RESORTS IN SOUTHWESTERN MAINE AND SOUTHEASTERN NEW HAMPSHIRE.

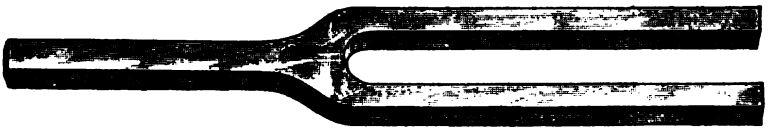
Summer vistiors to the famous resorts along the southwestern coast of Maine and the neighboring part of New Hampshire will welcome two new topographic maps just issued by the United States Geological Survey, Department Interior, covering areas in the vicinity of York and Portsmouth. The York map shows the coast line from Ogunquit Me. southward to Rye North Beach, N. H., also the towns of York, Kittery and part of South Berwick, Me. and the eastern part of Rye, N. H. At the southern extremity are shown the Isles of Shoals. The Portsmouth map, which will be of more service to those interested in the neighboring interior country as well as the coast, includes the area shown on the York map, also the cities of Portsmouth and Dover and the neighboring towns as far northwest as Rochester and as far southwest as Exeter.

The topography is shown in brown contour lines, and a special feature is the depiction of the relief of the sea bottom by blue contour lines which give striking evidence of coastal submergence. Many typical features of glaciation are well illustrated, and one of the most prominent is the Monadnock mountain Agamenticus, in York, which rises to an altitude of nearly 700 feet and is a prominent landmark visible for miles at sea and on clear days even from Cape Ann, Mass., about 40 miles away.

Copies of the York and Portsmouth maps may be purchased for 10 and 20 cents each, respectively, from the Director, United States Geological Survey, Washington, D. C.

Digitized by Google

TUNING FORKS



Designed especially for Student's Laboratory use. They are made in one piece, being cut from solid steel bars to insure the proper rigidity and elasticity for producing the best results. Accuracy to within one vibration.

C 128 Double Vibrations, 10 in. long.....$3.95

C_1 256 D. V., 7½ in.	$2.55	G_1 384 D. V., 7½ in.	2.40
D_1 288 D. V., 6¾ in.	2.55	A_1 426 D. V., 6 in.	2.30
E_1 320 D. V., 7 in.	2.45	B_1 480 D. V., 5¾ in.	2.25
F_1 341 D. V., 6¾ in.	2.40	C_2 512 D. V., 6¼ in.	2.25

Catalog S-20 lists a complete line of Scientific Apparatus and Supplies. Send for your copy NOW

E.W.A. ROWLES CO.

·MANUFACTURERS·
SCHOOL FURNITURE AND SUPPLIES
2345-51 SO. LA SALLE ST.
CHICAGO, ILL.

HOUSEHOLD ARITHMETIC

By KATHERINE F. BALL, M. A.,
Vocational Adviser for Women, University of Minnesota,

and

MIRIAM E. WEST, M. A.,

Teacher of Mathematics, Girls' Vocational High School, Minneapolis.

39 Illustrations. $1.48.

An arithmetic for girls, constructed to meet the special problems of the home and to accustom them to the solution thereof. Recognizing that the experiences of men are not those of the home, the authors here present a text, drawing its material from the common experience of the home maker, and building up through the familiarity of these experiences a command of the essentials of arithmetic.

The text is arranged according to the phases of home economics and correlates perfectly with home economic courses, which makes arithmetic much more attractive to the girl because the problems dealt with are those with which she comes in contact in everyday life. The pedagogy is modern and sound; although in a sense a review arithmetic, the book presents its topics in the simplest and most thorough manner. It is possible to divide the book into the parts of arithmetic lying within certain definite household fields—see table of contents.

J. B. LIPPINCOTT COMPANY

East Washington Square, Philadelphia, Pa.

2126 Prairie Avenue Chicago, Ill.

Digitized by Google

PRODUCTION OF ASPHALT IN THE UNITED STATES.

A preliminary estimate of the production and sales of asphalt and native bitumens and allied substances in the United States in 1919 has just been made public by the United States Geological Survey, Department of the Interior. The asphalt produced from domestic petroleum amounted to 600,000 short tons, valued at $9,000,000 an apparent increase over 1918 of 72,425 tons and of $1,564,796 respectively. The asphalt produced from Mexican petroleum amounted to 672,000 short tons, valued at $7,917,000 an increase from 1918 of 21,756 tons in quantity and a decrease of $1,407,020 in value. About 115,000 short tons of native bitumens and allied substances valued at $1,000,000 was produced in 1919, an apparent increase over 1918 of 54,966 tons and of $219 192.

VARIETY IS THE SPICE OF LABORATORY WORK

By C. C. Leeson,

State Teachers College, Maryville, Mo.

There is abundant opportunity for a wide variety of activities in the laboratory work of General Biology, Science or Nature Study. To make the most of this variety will give training in methods of work as well as in scientific facts and principles. Not infrequently anatomical work and diagramatic and written records usurp most of the time. Often lower types only are studied and the student never gets as far as the more practical phases of birds and mammals. My own experience as a college student gave me no greater variety than the above mentioned.

The purpose of this article is to cite and give representative problems under fifteen different types of laboratory work. The teacher of science will do well to outline the laboratory problems of a given subject or term so as to include as many of these types as possible.

I. The illustrated lecture.—Students make small charts, 4x4 inches, or reflectoscope pictures on such topics as—bird attraction, insect control, rural sanitation, weeds, ornamental planting, etc. These are given as lectures with genuine value and interest.

2. Collection making.—Each student chooses a different topic and near the end of the term displays and explains all he knows about each specimen. Some good collections are: tree barks, buds, fruits, leaves, vines, poisonous and medicinal weeds, insect pollinated flowers, protective devices, nature photos, butterflies, harmful insects, etc.

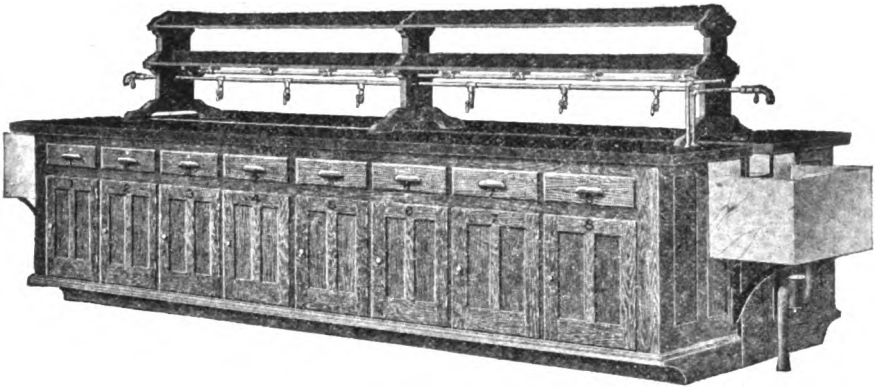
3. Game day.—Nature conundrums, bird picture games, naming contests on numbered pictures and objects, dramatic presentations, nature games and contests of the boy scouts and camp-fire girls. Get ideas from the students and make this a real educative holiday.

4. Continued project.—Keep an aquarium stocked, window box care, starting young plants, potato planting experiments, flower culture, ornamental plan carried out, rearing caterpillars and insects, studies in animal behavior, with a migration record, etc. Students may work in pairs or groups with a chosen leader.

5. Construction.—This should include not only the making of a device but the plan drawing, practical use and correlated work of other subjects. A selection from which to choose are: fly trap, nesting boxes, aquarium rearing cage, collecting outfit for insects, demonstration ant nest, mechanical toys, etc.

6. Survey.—A plot of ground may be mapped with its actual and probable plant and animal distribution, bird nests, contour; or a health survey, a sanitary survey of dairies, stores, etc.; a survey of ornamental plantings, poultry varieties, pets and breeds of domestic animals, mosquito and fly breeding places.

Digitized by Google



Students' Chemistry Desk No. 862. Exposed plumbing and troughs. Accommodates 16 students working in sections of eight.

"Without Qualification"

To praise a manufactured product "without qualification" implies that it occupies a unique and unusual position in its field.

We have always claimed for Kewaunee this position in the field of School Laboratory Furniture, and it is refreshing to have our opinion endorsed so completely.

A well known California Principal wrote as follows:

"Without qualification I would pronounce your products the finest human genius and skill have yet produced. I heartily appreciate your effort to coordinate your labors with ours in the school room, in an endeavor to raise the standards of cleanliness, economy of time, and efficiency among our young people. It would be difficult for me to suggest a real improvement upon your laboratory furniture."

Address all inquiries to the factory at Kewaunee.

Kewaunee Mfg. Co.

LABORATORY FURNITURE EXPERTS

114 Lincoln Street

Kewaunee, Wis.

New York Office, 70 Fifth Avenue

BRANCH OFFICES:

Chicago	Atlanta	Dallas	Kansas City	Spokane
Columbus	Alexandria, La.	El Paso	Minneapolis	San Francisco
	Little Rock		Denver	

Digitized by Google

7. Field trip.—To identify birds, trees, weeds, wild flowers, mosses and ferns, to observe ornamental plans and plants, adaptive structure and habits of plants and animals, plant distribution, to collect laboratory or museum material.

8. Demonstration.—Some known principle or fact is verified in the laboratory, such as transpiration, photosynthesis, osmosis, phototropism, diffusion, etc.

9. Experiment.—An unknown reaction or quantitative result is determined, such as: amount of transpiration, rapidity of growth, optimum temperature for growth, relation of oxygen to germination, etc.

10. Dissection and anatomical study. This type of work is often overdone, and laboratory directions are often so explicit as to leave nothing but thoughtless routine for the student.

11. Microscopic observation.—Micro-organisms, cells, tissues, staining effects, mitosis, etc., with some microscopic technique.

12. Tabulated studies of collections.—The various collections that students may build up in a laboratory may be analyzed and recorded in columns such as for seed dispersal; name, by what carried, carrying device, sketch.

13. Cooperative project.—Planning and planting home grounds or school grounds, flower beds, garden plots, making a card catalogue of library topics, or laboratory exercises, collecting a school herbarium, making a loose leaf bird-house book, giving a dramatic presentation, etc.

14. Illustrating facts and stories by graphs or free hand drawings, diagrams, models, pantomine, etc. The teacher may give statistics and ask for graphical representation, or read a story which is to be pictured by free hand sketch or vice versa.

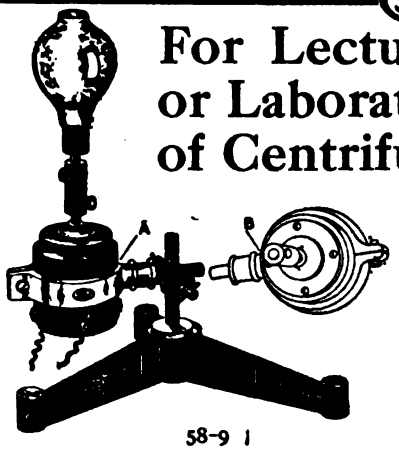
15. Exhibition day.—The best displayable work of the term is selected and arranged for public observation in corridor or display cabinet.

NOTES AND NEWS CONCERNING THE WORK OF THE NATIONAL COMMITTEE ON MATHEMATICAL PROBLEMS.

(September 15, 1920.)

The National Committee on Mathematical Requirements held a meeting at Lake Delavan, Wisconsin, on September 2, 3, and 4, at which a number of reports were discussed and adopted. A report on The Revision of College Entrance Requirements received the greatest amount of discussion. It is hoped that this report may be released for publication early in October. It includes a general discussion of the present problems connected with college entrance requirements in mathematics, a report of an investigation recently made by the National Committee concerning the values of the various topics in elementary algebra as preparation for the elementary college courses in other subjects and a suggested revision of the definitions of entrance units in elementary algebra and plane geometry. In connection with the suggested requirements in plane geometry a list of fundamental propositions and constructions is attached. This list includes the proposition which may be assumed without proof or given informal treatment, a list of the most fundamental theorems and constructions from which it is intended that questions on entrance examination papers other than originals be chosen, and a list of subsidiary theorems. It is proposed to prepare a mimeographed edition of this list of propositions and constructions at the earliest possible moment, for the benefit of such teachers as may desire to make use of it in connection with their classes during the coming year. A copy will be sent to any person interested upon application to the Chairman of the Committee, J. W. Young, Hanover, New Hampshire.

Digitized by Google



58-9

For Lecture Demonstration, or Laboratory Application, of Centrifugal Force . . . . .

You Need This Waverley Electric—
A Whirling Machine and Centrifuge Combined.

As a whirling machine the Waverley-Electric takes a Centrifugal Globe (as illustrated), or Double Hoops, Centrifugal Balls, and other accessories.

A Centrifuge Head converts the Waverley-Electric into a powerful centrifuge that may be used with efficacy for the analysis of milk, urine, blood, or other liquids.

The specially designed, ball-bearing motor is mounted and balanced to operate in vertical or horizontal position. Consequently its general utility includes the rotation of Savart's Wheels, Siren Discs, Newton's Color Discs and the like.

The Waverley-Electric Specifications

Support—Standard Tripod.
Yoke—Cast Aluminum.
Housing—Enameled Iron.
Motor—6,000 R. P. M.
Mica Insulation. Self-Adjusting Brushes.
Ball-Bearing Shaft.
Current—D. C., A. C., or Dry Cells.
Chuck—Universal.

58-9 The Waverley-Electric, including Support, Yoke, Motor and Chuck.....$19.00
58-9a Waverley Centrifuge Head, four-arm.. 3.75

Cambridge Botanical Supply Company

LABORATORY EQUIPMENT—ALL SCIENCES

1-9 Lexington Street **1884-1920** **Waverley, Mass.**

Happy School Days Are Assured for Teacher and Pupils

Where Blakiston texts are used, the pupil is inspired to study, and the teacher is saved unnecessary explanations of subjects that should be clearly presented in the book.

FOR YOUR CONSIDERATION

Gager—
FUNDAMENTALS OF BOTANY
By C. STUART GAGER,
Director Brooklyn Botanic Garden.
435 Illustrations. Cloth. $2.00 Postpaid.

Neufeld—
ELEMENTARY ALGEBRA
With Table of Logarithms
By J. L. NEUFELD.
Central High School, Philadelphia.
Illustrated. 12mo. Cloth. $1.45 Postpaid.

Tower, Smith, Turton—
PRINCIPLES OF PHYSICS
By WILLIS E. TOWER, Chicago, CHARLES H. SMITH and CHARLES M. TURTON.
425 Illustrations. Cloth. $1.25 Postpaid.

Holmes—
ELEMENTS OF ANIMAL BIOLOGY
By A. J. HOLMES, University of California.
249 Illustrations. Cloth. $1.35 Postpaid.

P. Blakiston's Son & Co. Publishers PHILADELPHIA

Digitized by Google

A preliminary draft on Mathematics in Experimental Schools was discussed at this meeting. Raleigh Schorling of the Committee has spent over a year collecting material for this report. It is hoped that it will be ready for publication early next spring. The report will be an extensive one and will describe in detail the work actually done in mathematics in experimental schools throughout the country.

Miss Vevia Blair of the committee presented her report on the Present Status of Disciplinary Values in Education. It is expected that this report also will be released for publication in October. It gives a critical review of the complete literature concerning the experimental work on the transfer of training as well as an evaluation of this literature terminating in the formulation of certain propositions concerning disciplinary values which appear justified by the experimental work. A particularly valuable feature of the report would seem to lie in the fact that a large majority of the most prominent psychologists in the country appear to be ready to subscribe to the propositions formulated.

Professor E. R. Hedrick presented a report which he prepared at the request of the National Committee on "The Function Concept in Secondary School Mathematics." This report also will be published in the near future and is intended ultimately to form a part of the final report of the committee on the reorganization of the first courses in Secondary School Mathematics. A preliminary report on this subject was published for the committee by the U. S. Bureau of Education last February as Secondary School Circular No. 5.

A preliminary report on Junior High School Mathematics is in the press of the U. S. Bureau of Education and should be ready for distribution early in October. The National Committee desires the assistance of its cooperating organizations, which now number about 70, in the revision of this preliminary report. Comments, suggestions and criticisms should be sent to the chairman of the committee not later than January 1, in view of the fact that the committee expects to take up the formulation of its final report on this subject immediately after this date.

A subcommittee under the chairmanship of Professor C. N. Moore is preparing a report on "Elective Courses in Mathematics in Secondary Schools." A committee under the chairmanship of Professor David Eugene Smith is preparing a report on "The Standardization of Terminology and Symbolism," and Professor R. C. Archibald is preparing one on "The Training of Teachers." It is expected that all three of these reports will be presented for the consideration of the National Committee in October.

The work of the National Committee and its recommendations were discussed in teachers classes at the summer sessions of colleges, universities and normal schools throughout the country. Addresses on the work of the committee were given as follows: By Mr. Raleigh Schorling at Harvard University, by Professor E. R. Hedrick at the Universities of Texas and of Oklahoma, and by J. A. Foberg at the Universities of Iowa and Minnesota.

Present indications point to the fact that the work of the National Committee will have a prominent place on the programs of most teachers organizations throughout the country during the coming year. The National Committee stands ready as before to help in every possible way in the preparation of such programs and will be glad to furnish material for discussion.

It will also be pleased to furnish speakers for such meetings to the extent of its ability.

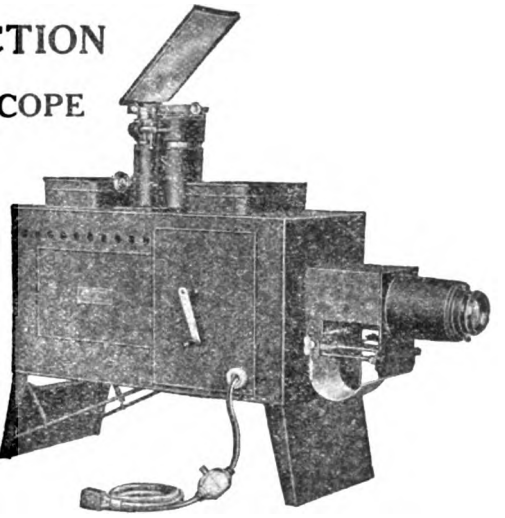
Digitized by Google

VISUAL INSTRUCTION
WITH
SPENCER DELINEASCOPE MODEL 3

is made perfect because it is an IDEAL STEREOPTICON for both lantern slides and opaque objects, such as pictures, post-cards, reading matter and objects of all kinds dead and alive.

IDEAL, because it embodies basic ideas (patented) possessed by no other. Example: Mechanical means of handling the slides, which does away with the antiquated lantern-slide holder and at the same time gives a "dissolving effect" on the screen unattained with other outfits except by using two stereopticons, one above the other.

One Spencer Delineascope does it.



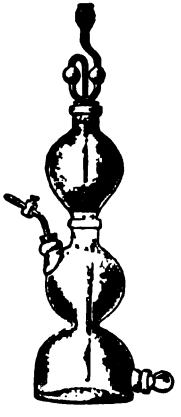
Spencers Delineascope Model 3 for both lantern slides and opaque objects. 1,000 Watt Mazda bulb illuminant. **Price, $185.00**

SPENCER BUFFALO U.S.A.

SPENCER LENS COMPANY
Buffalo, New York

Manufacturers of **Microscopes, Microtomes, Delineascopes, Optical Glass, Scientific Apparatus, Etc.**

SPENCER BUFFALO U.S.A.



No. 2402

We Carry a Complete Stock of

Chemicals & Apparatus

for the

Physical

Agricultural

Chemical

Biological

Laboratory

We Excel in Equipping High School Laboratories.
Let Us Quote Prices on Your Next List of Requirements.

THE KAUFFMAN-LATTIMER CO.

41 East Chestnut Street
Columbus, Ohio

Digitized by Google

EFFECT OF A FLORIDA FREEZE ON INSECTS.

The disastrous Florida freeze of February 2-4, 1917, which killed or practically defoliated the citrus trees in Putnam, Volusia, and Marion Counties, and parts of Lake and Orange Counties, and heavily damaged trees in other sections of the State, was of considerable importance in "reducing the numbers of injurious pests which infested the trees." In the section where temperatures as low as 15° or 20° F. occurred the freeze or the falling and drying of the leaves nearly exterminated the rust mite and varieties of white fly and scale insects. Few adult specimen of the various species survived except on fired or otherwise protected groves or individual trees. Of the red scale it is believed that perhaps not more than one in 100,000 remained alive. The almost complete extermination of this species by the freeze and its reproduction to billions in six months is a most remarkable biological fact. In some instances there was no need of the usual early spraying yet, singularly enough, in most cases the normal number of insects appeared in the following summer or fall. So, as a rule, the setback in insect life, however great even over the area of maximum freeze, was only temporary.—*W. E. H.* in *Monthly Weather Review.*

THE TEACHING OF GEOGRAPHY AND THE WORLD WAR.

By H. E. Branom,

Harris Teachers College, St. Louis.

At the outbreak of the World War the emphasis in the teaching of geography had shifted from locational and descriptive to interpretative and relational geography. Facts were still needed, and memory work was held in high esteem, but an attempt was made to interpret the interacting relations between man and his physical environment. The standard topical outline, in many instances, was retained, but each of the topics, as location, area, topography, climate, life forms, and human activities, was considered from the standpoint of its influence on man and his activities.

During the World War, every member of the social group, including the children, led an intensified intellectual existence. Even the children were asked to assist in numerous ways. They eagerly responded, because they had an opportunity to engage in worth-while, purposeful activity, the product of which was helpful in strengthening our army and navy in overcoming our aggressive enemies. The spontaneous, hearty response indicated the importance of confronting the pupils with situations which make a strong appeal.

The study of home geography received an additional impetus. In each community factories engaged in manufacturing activities that directly contributed to the winning of the war were run at full capacity. Factories engaged in the production of "non-essentials" were shut down or their output was restricted. This expansion and contraction of industries affected directly the community life and stimulated the people, through the interest aroused, to attempt to interpret the local economic activities. The shortage of products, as sugar and wheat flour, and the dependence of the local area on far away lands for products and for markets, aroused an interest, with the community as a point of departure, in the world as a whole. The teacher, recognizing the value of using the social interests in her geography work, placed increasing emphasis on home geography, not only because of its intrinsic value—but because of its usefulness in the interpretation of the far away.

The War strongly suggested the desirability of approaching the study of geography from the social viewpoint. The War fundamentally arose out of a difference in ideals among the groups of people. The attention

Digitized by Google

"The Best Physical Geography on the market"
"Beats all others"
"Found no other that approaches it in thoroughness"
"The book by Hopkins is great"

are just a few of the many expressions of satisfaction with which the science teachers of the country hailed the appearance of

HOPKINS' ELEMENTS OF PHYSICAL GEOGRAPHY

NEW EDITION (1919)

PROFESSOR HOPKINS presents his subject in such an interesting and attractive manner that his book not only gains but also holds the attention of the pupils. By his lucid and clear style he has made clear even such difficult topics as the nebular hypothesis, the tides, the eclipses, etc. The text is supplemented by hundreds of illustrations, most of them from photographs taken by Professor Hopkins expressly for this book and found nowhere else.

528 pages. 355 illustrations. 4 colored maps.

BENJ. H. SANBORN & CO.

Chicago New York Boston

Questions For Reviews

75,000 Already Sold

Compiled from Recent College Entrance Examinations

Separate pamphlets. Price 40 cents each. Liberal discounts on quantity orders. Sample copy half price. Copy for teacher free on adoption for class use. Answers to numerical problems can be supplied to teachers only. Prices on application.

Algebra
Chemistry
Physics

By Franklin T. Jones

Plane Geometry
Solid Geometry
Trigonometry

French A, and B; German A, and B;
English; First, and Second Latin;
Question Book on History (Greek, Roman, American, English)
Medieval and Modern European History

Write for prices and information

University Supply & Book Company

Digitized by Google

of the people was first drawn to the various disagreements among the groups. An understanding of the different viewpoints, however, required a knowledge of the varying physical backgrounds. In the great clash of nations, inequalities in the distribution of valuable plants, animals, minerals, and transportation facilities were significant in determining the outcome. In attempts to socialize the work teachers had tended to forget the physical background. The dependence of nature's resources emphasized the need of securing a social reorganization of the course of study on a physical basis. The geography problems arose out of the social situation and required the physical factors for their interpretation.

The interest aroused in various parts of the earth created a heavy demand for geographical books, magazines, maps and globes. This need was met in part by making use of the dust-covered materials of the schools, in part, by the purchase of new equipment. Better facilities for the teaching of the subject and a more intelligent use of equipment helped to popularize geography.

With the removal of the unusual stimulus afforded by the World War, teachers have sought a satisfactory substitute, by appealing to the child's interests and experiences through current events and the use of local industries and physical features. It is no longer held that the best teaching can be accomplished through a standardized outline. Each area is studied from the standpoint of the more important problems and the various parts of the old topical outline are emphasized according to their relative values in helping to solve the problems.

The project-problem is being emphasized more and more. Several large school systems have attempted to organize all of their regional geography on this basis. An introductory discussion, appealing to the child's interests and experiences, may arouse in the minds of the class a worth-while problem. Materials bearing on the problem are secured, and through their interpretation and evaluation the problem is solved.

The problem, Should Great Britain encourage the establishment of an Irish Republic? may be thrust before the class, but, preferably, a brief discussion of the Irish situation related to current events may cause the problem to arise. After the problem is raised and concisely stated, the economic, social, religious, and strategic factors having a bearing on the problem will be discussed in the light of the physical background. After a thorough discussion the problem is solved or the material is summarized.

In directing the discussion of problems considerable ability is required, for it scarcely can be expected that any representative group, even among children, will come to a unanimous agreement concerning all social problems. We are coming to believe that vital problems should be discussed and we are coming to judge a teacher, in part, by the skill she shows in developing all parts of a problem, in securing a free and easy discussion, in getting the children, although perhaps disagreeing, to respect the opinions of each other, in teaching children how conscientiously to discuss problems over which there may be serious disagreement and yet to continue to dwell together in brotherly love.

TREMENDOUS SNOWSTORM IN PALESTINE, FEBRUARY 9-11, 1920.

By Otis A. Glazebrook,
American Consul.

On the afternoon of February 9, 1920, a maid of the consulate ran into the house gleefully showing a handful of snow which she had pressed into a snowball. It was the first snow she had ever seen. As the weather had been constantly inclement since the middle of November, 1919, I supposed

Digitized by Google

Modern Junior Mathematics

By MARIE GUGLE

Assistant Superintendent of Schools, Columbus, Ohio

is the latest and most complete reorganization of the course in mathematics yet published. A three-book series, brand new from the ground up, equally suitable for junior high schools or for 7th, 8th and 9th grade classes. The book recognizes the modern trend in the teaching of mathematics, and follows very closely the recommendations of the National Committee.

Modern Junior Mathematics meets the child *as he is*. The series recognizes that advanced arithmetic demands a maturity of thought that places it rightly in the high school course of study; that, on the other hand, mathematical relations are taught best through experimentation and observation in the intermediate schools at the time when the pupils are primarily "doers."

THREE BOOKS

Book I is singularly happy in the elimination of stereotyped phraseology and archaic subject matter. The graph is used constantly to illuminate the different phases of arithmetic. The application of principles to every day business transactions is vividly presented.

Book II breaks absolutely with tradition. It introduces the subject matter in a new way. The pupil, doing and thinking for himself, learns to use formulas and algebraic expressions as convenient tools. He becomes familiar with the common geometric forms and grows to think naturally and without confusion in the terms and relations of geometry.

Book III, like the others, reflects the reorganization of such teaching necessitated by the phenomenal growth in popularity of the junior high school. The elements of arithmetic, geometry, algebra, and trigonometry are, more and more, being taught as one subject in seventh, eighth, and ninth years.

In this series Books I and II, while largely arithmetical and geometric respectively, are not rigidly confined to one field or the other, and Book III likewise, while largely algebraic, aims to give new meaning to arithmetic number relations and processes, while geometry continues to give meaning to algebra and offers with trigonometry an interesting field of application.

List prices, Book I—80c; Book II—90c; Book III—$1.00

Examination copies will be sent to any teacher, postpaid, upon receipt of 75 per cent of the list price. Samples may be returned for credit.

THE GREGG PUBLISHING COMPANY

NEW YORK CHICAGO BOSTON SAN FRANCISCO

Digitized by Google

that this was but a snow flurry ending the former rains, as over 27 inches of rain had already fallen, this quantity being far above the average at this time of the year. In 36 hours afterwards, however, Jerusalem and the surrounding country for miles had been mantled by a snowfall which averaged on the level 40 inches, with drifts in many places reaching a height of 10 feet.

In the memory of the inhabitants of Jerusalem this was the greatest snowfall and the people were absolutely appalled by it. I recall the great blizzard of 1888 and remember many other heavy falls of snow in the United States, but none compared in possibilities of danger to this one. The locust visitation of 1915 falls into insignificance as compared with it. The people of this country being unused to such a phenomenon were totally unprepared to contend with it. There were no snow plows or even snow shovels, and if there had been the population would not have known how to handle them. All communication within the snow limit was interrupted, and the falling of the telegraph wires, the blocking of the railroad and all thoroughfares cut us off entirely from the outside world. Every store was closed. The Felahin could not bring their products to the markets. There was a shortage of bread and a dearth of wood and kerosene, and starving and freezing faced the people. Fortunately, there is a battalion of Yorkshire troops garrisoning the city. This battalion saved the situation. At once over 700 men were at work with shovels opening the roads and streets in the city and digging out the buried population. When the stores were opened the spirit of profiteering which was already remorselessly abroad in this community—causing the prices of all necessaries, not to speak of luxuries, to increase from five to ten times their former value, having made Jerusalem in the past year possibly the most expensive place in the world, the cost of living being twice as high as in Egypt and in Syria—knew no restraint. In consequence, mob violence was imminent and the military governor was compelled to strenuously reduce the price of bread and other food commodities.

At least 40 houses in Jersualem were crushed in by the weight of the snow, but, strange to say, the casualty list is comparatively short. When at last unfettered, the inhabitants in general proved equal to the occasion by sharing their own provisions with the poor and improvident. Conditions are now normal, the telegraph and railroad lines being in operation, stores opened, and native products coming into the market. The snow has rapidly disappeared, and except for the continued high winds and unusually cold weather one would not believe that the city had just raised itself from the dead. This blizzard will go down to history as one of the most remarkable and dangerous occurrences in the history of the Holy City, a city by no means unacquainted with extraordinary incidents.—*Monthly Weather Review.*

HILGER DIFFRACTION GRATING.

Every science student is acquainted with the theory of the diffraction grating, and the enormously important work done with diffraction gratings in advancing the study of luminous radiation. Owing to the expense of original ruled diffraction gratings, as made on the Rowland Machine at the Johns Hopkins University, and the greatly less, but still not insignificant, cost of the excellent copies made by various firms, it has not been possible to place a diffraction grating in the hands of every science student.

This position has now been remedied by the firm of Adam Hilger, Limited, of 75 A, Camden Road, London, N.W.1.

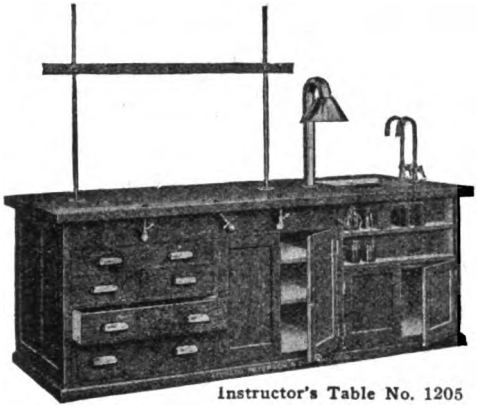
Digitized by Google

Leonard Peterson & Co. *Inc.*

Pioneer Designers and Manufacturers of

High Grade Laboratory Furniture

For Chemistry, Physics, Biology, Physiography, Domestic Science, Domestic Art, and Manual Training.



Instructor's Table No. 1205

Superior quality, strength, solidity, and durability are built right into our furniture. Every detail is well worked out. Our furniture has met with the approval of hundreds of educators thruout the United States, Canada, Porto Rico, and China.

Send for a copy of our general catalog No. 10.

Leonard Peterson & Co., Inc., 1234-48 Fullerton Ave., Chicago

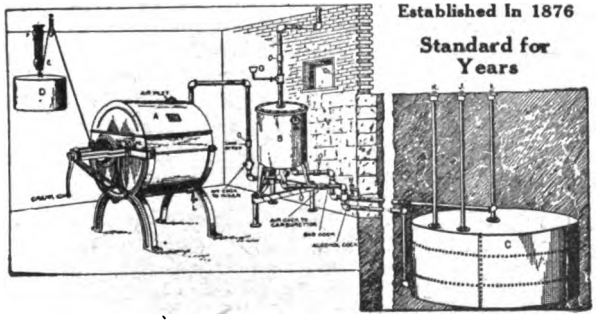
MANUFACTURERS OF GUARANTEED LABORATORY FURNITURE

New York Office: Grand Central Palace, New York City

Back numbers of School Science, School Mathematics, and School Science and Mathematics may be had for 30 cents a single copy. The Mathematical Supplements for 15 cents a copy.

In sets the prices are, postpaid:

School Mathematics and Supplements, Vol. I, five numbers	$1.00
School Science, Vol. I, eight numbers	6.00
School Science, Vols. II and III, each	6.00
School Science, Vol. IV, three numbers	.75
School Science and Mathematics, Vols. V, VI, VII, VIII, IX X, XI, XII, XIII, XIV, XV, XVI and XVII, each	2.00
School Science and Mathematics, Vols. XVIII and XIX	2.50



Established In 1876

Standard for Years

This Machine Will Produce

Automatically

GAS

For your laboratories, Domestic Science Department and for lighting.

* * *

In use in hundreds of educational institutions throughout the country.

Write to us for a list of colleges and high schools using our machine.

Illustrated Catalogue Will be Sent on Request.

MATTHEWS GAS MACHINE CO.

180 N. Dearborn Street, CHICAGO, ILLINOIS

Digitized by Google

Each of the new, cheap gratings supplied by them consists of a smal patch, about one-half inch square, consisting of a celluloid cast of an original Rowland grating, mounted between two protecting plates of glass. The number of lines per inch is printed on each grating. The gratings are not intended for use in a spectroscope, for which they are insufficiently accurate; but for use in the hand in the following way:

SOLAR SPECTRUM.

With the back to the sun, take an ordinary bright needle, and so hold this that a bright, scintillating line of light is seen on the needle with the naked eye. Then interpose between the needle and the eye the diffraction grating. If the eye is then turned to look sideways an extended solar spectrum will be seen with the Fraunhaufer lines distinctly displayed.

FOR LABORATORY AND CLASS WORK.

If one looks from a distance through the grating at a Bunsen flame, in which is held a piece of asbestos soaked in sodium, potassium, lithium, etc., salts, the monochromatic images of the flame will be seen in their correct positions in the spectrum. Better still, if through the grating one looks at a spark discharge, or, best of all, the light reflected on a needle (as in the sun spectrum) from an ordinary flame arc, or even looks at a street arc lamp from a distance through the grating, a brilliant metallic emission spectrum will be seen.

These gratings form the readiest means hitherto available of demonstrating a spectrum to a class.

These gratings may be obtained from the following agents:

Arthur H. Thomas Co., West Washington Square, Philadelphia, Pa.
James G. Biddle, 1211-13 Arch Street, Philadelphia, Pa.
Braun-Knecht-Heimann Co., 576 Mission Street, San Francisco, Cal.
Eimer & Amend, Third Avenue, 18th to 19th Streets, New York City.
Central Scientific Co., 460 East Ohio Street, Chicago.
Scientific Materials Co., 711-719 Forbes Street, Pittsburgh.
Palo Company, 90-94 Maiden Lane (P. O. Box 1067), New York.
E. H. Sargent & Co., 125-127 West Lake Street, Chicago.
Or direct from Messrs. Adam Hilger, Limited, of 75 A, Camden Road, London, England, N.W.1, on remitting a postal order for 2 Shillings per grating, or 21 Shillings per dozen.

NOTES AND NEWS REGARDING THE WORK OF THE NATIONAL COMMITTEE ON MATHEMATICAL REQUIREMENTS.

The National Committee on Mathematical Requirements held a meeting in Chicago on April 23d and 24th, 1920. The principal topic discussed at this meeting was the preliminary report on "Junior High School Mathematics" prepared for the Committee by Mr. J. A. Foberg. After detailed discussion and some amendment and revision, the report was adopted by the Committee and its publication as a preliminary report authorized. It has been submitted to the U. S. Bureau of Education for publication as one of its secondary school circulars.

This report considers briefly the history of the Junior High School Movement, its purposes and organization; it proposes certain general principles to govern the organization of work in mathematics in the junior high school and considers in some detail the topics to be included. The Committee feels that much experimentation must still precede any attempt at standardization of the junior high school curriculum in mathematics. Its recommendations are intended to form the basis of study, discussion and class room experiment. To this end the cooperation of teachers and supervisors is earnestly solicited. The National Committee hopes to act as a clearing house for constructive criticism based on actual class room experience.

The following resolution was adopted:

Digitized by Google

Central Association

THE twentieth meeting of the Central Association of Science and Mathematics Teachers will be held at the Englewood High School, Chicago, on November 26 and 27.

The general program on Friday morning, November 26, will consist of the following important papers:

W. D. RICHARDSON, Chief Chemist of Swift & Co., on Relations of Science and Mathematics to Business and Industry.

PROFESSOR B. R. BUCKINGHAM, Director of the Bureau of Educational Research, University of Illinois, on Mathematical Ability as related to General Intelligence.

PROFESSOR DONALD F. CAMPBELL, Armour Institute, on Essentials of a Sound Pension System.

Science and Mathematics Teachers are urged to avail themselves of the opportunity to join the Central Association if they have not already done so. All teachers of Science and Mathematics should arrange to attend this twentieth annual meeting of the Association, at the Englewood High School, Chicago, on the Friday and Saturday following Thanksgiving.

The section programs have been arranged with much care, and exceedingly profitable and interesting meetings are assured for each of them. These section meetings are arranged for Friday afternoon and Saturday morning.

Digitized by Google

RESOLVED: That the National Committee on Mathematical Requirements approves the junior high school form of organization and urges its general adoption in the conviction that it will secure greater efficiency in the teaching of mathematics.

Reports of progress were made by subcommittees on The Training of Teachers, Experimental Schools and Courses, Disciplinary Values and Transfer of Training, Elective Courses in Mathematics for High Schools, and Mental Tests. It is expected that preliminary reports on all of these topics will be ready for consideration by the Committee at its next meeting on September 2nd, 3rd and 4th. The attention of experimental schools throughout the country is called to the report on this subject being prepared for the Committee by Mr. Raleigh Schorling of the Lincoln School, New York City. Any experimental schools or schools giving experimental courses in mathematics who desire to be represented in this report should communicate with Mr. Schorling without delay, if they have not already done so. A subcommittee on the Standardization of Terminology and Symbolism with Professor D. E. Smith as Chairman and a subcommittee on Junior College Mathematics with Mr. A. C. Olney as Chairman were appointed. J. W. Young, Raleigh Schorling, and W. F. Downey were authorized to take steps to initiate investigations into the mathematical elements entering into various industries, professions, vocations, etc.

A budget for the coming year based on the recent appropriation of the General Education Board of $25,000 for the use of the Committee in completing its work was adopted. It is hoped that the increase in the item allowed for traveling expenses in this budget will make it possible for representatives of the Committee to reach educational meetings in all sections of the country where such representatives are desired to discuss the various reports of the Committee. Nearly 70 organizations are at present actively cooperating with the Committee and it is hoped that many others will communicate with the Chairman in the interest of furthering the nation-wide study and discussion which is already under way. J. W. Young, 24 Musgrove Building, Hanover, New Hampshire, and J. A. Foberg, 3829 North Tripp Avenue, Chicago, Illinois, were reelected Chairman and Vice-Chairman, respectively, of the Committee for the ensuing year.

"THE INDIVIDUAL AND THE CURRICULUM: EXPERIMENTS IN ADAPTATION." This is the title of the sixth volume of the *Francis W. Parker School Studies in Education* (a series of booklets published by the Faculty, and formerly entitled *Year Books*). Surely no subject is more vital to thoughtful teachers of today. Although they may believe with heart and soul that real education means the teaching of individual human beings rather than subject matter, they are nevertheless thwarted in the practice of this faith at every turn by the required cast-iron courses of study designed for a wholesale, machine-made "human" product.

Miss Jennie Hall's article on the trial of the individual project method in a seventh grade class shows what can be done in a school where freedom for experimentation exists, to develop through the daily work, the special interests and distinct personality of each child. The idea is not given, as too frequently happens in educational publications, in its theoretical stage. It is the account of a year of actual practice. The daily schedule, the home study, the teacher's plan for estimating the values of the work for each child, are made clear by illustrative charts as well as by thorough explanation.

Digitized by Google

Wiese Laboratory Furniture Co.

Engineers and Builders

Educational and Technical Furniture for Physics, Chemistry, Agriculture, Biology, Household Economics

The art of building laboratory furniture is as definite and exact as science itself. The Wiese factory is prepared to furnish durable, satisfaction-giving laboratory equipment of standard design or special order

Without cost or obligation to you, we extend the services of our engineering department in planning your laboratories. To make sales is not enough—we want to make friends

Write for Our
New Catalog No. 24

WIESE LABORATORY FURNITURE CO.

Sales Office:
20 E. Jackson Blvd. :: Chicago, Illinois

Factory:
Manitowoc, Wisconsin

Digitized by Google

Much of the average child's power of intellectual growth is wasted because the subject matter offered him for the exercise of this power does not command his sympathy and willing effort. The individual project method is the freest solution of this difficulty. But there are other ways of preventing this waste of energy in irksome and unproductive study. Experiments and methods within the scope of the more usual class room work of any school are sketched in a group of articles entitled *Social Interest in the Class Room.* These articles contain suggestions—in the form of records of actual work done—for bringing almost every study in the average school course into definite relation with the compelling interests of the time or of the individual child.

Four very different studies of Lincoln, made by four different eighth grade classes, are given in the form of verbatim reports of the Lincoln Exercises before the school assembly, programs which culminated the class study each year. Practical interests of today in the high school science work, the development of the correspondence scheme in modern language study, the relinquishing of all textbook arrangements of the civics course in order to make it bring to the child certain vivid experiences—these are typical examples of the contents of this section. It is followed by a very concrete and graphic report of a group of community adventures in the school—a paper-saving campaign, a war-service bankbook, a postage-saving device, etc.—which point out the great wastefulness of the average American, and which suggest ways of making thrift not only a habit, but also the basis of genuinely educative class room work.

The next group of articles shows the articulation of the art and eurythmics work with other subjects of the child's study. But more than this, it indicates at every point the enrichment of the entire conscious life of the child through adequate opportunity for aesthetic experiences of all sorts, experiences which use every faculty, which make for many new contacts, and which leave the child free to express what is his own. The clear explanation of the Jaques-Dalcroze method of eurythmics as taught in the Parker School by one of his pupils will be helpful to schools contemplating the introduction of rhythmic gymnastics into their course of study.

While less focussed upon one phase of the study than previous numbers of the *Studies in Education,* this volume is especially valuable in giving a cross-section of the school life as it is influenced by one of the underlying principles of the school.

160 pages, 38 illustrations, 4 colored plates—price 45 cents.

ARTICLES IN CURRENT PERIODICALS.

American Mathematical Monthly, for October; *Lancaster, Pa.:* **$4.00** *per 1 year,* 50 *cents a copy:* "The Average Reading Vocabulary; An Application of Bayes's Theorem," Warren Weaver; "A Graphical Aid in the Study of Functions of a Complex Variable," Norman Miller; "Modular Geometry," A. A. Bennett; Questions and Discussions: "Note on the solution of fractional equations," C. A. Noble; "Determination of an angle of a right triangle without tables," R. A. Johnson.

Geographical Review, for July; *Broadway at 156th Street, New York City:* **$5.00** *per year,* 50 *cents a copy:* "Cape Cod and the Old Colony," Albert P. Brigham (1 map); "The San Blas Indians of Panama," S. P. Verner (5 photos); "New Orleans in Early Days," Edna F. Campbell; "Wandering Storms," Alexander McAdie (3 maps).

National Geographic Magazine, for October; *Washington, D. C.:* **$3.50** *per year,* 35 *cents a copy:* "Nepal: A Little-Known Kingdom," 33 illustrations, John C. White; "Human Emotions Recorded by Photography," 16 illustrations, Ralph A. Graves; "Tahiti: A Playground of Nature,"

Digitized by Google

School Science and Mathematics

Member of the Educational Press Association of America

No Numbers Published for JULY, AUGUST and SEPTEMBER.

PRICE. The subscription price is Two Dollars and Fifty Cents a year, if paid in advance; single copies 30 cents.

ALL REMITTANCES should be made payable to the order of **School Science and Mathematics. Remittances should be made by Post Office Money Order, Express Order, or Bank Draft.** If personal checks are sent, please add ten cents for collection.

SCHOOL SCIENCE AND MATHEMATICS is the "official organ" of the following associations: The Central Association of Science and Mathematics Teachers, Eastern Association of Physics Teachers, The Physics Club of New York, Missouri Society of Teachers of Mathematics and Science, Science and Mathematics Section of the Oregon State Teachers Association, Saskatchewan Science and Mathematics Teachers Association, Southern Pacific Science and Mathematics Teachers Association, Kansas Association of Mathematics Teachers New York State Science Teachers Association, New Jersey Science Teachers Association.

POSTAGE IS PREPAID for all subscriptions in the United States and Mexico. For Canada add 25 cents for postage. For all other countries in the Postal Union, add 50 cents.

CHANGE OF ADDRESS. Subscribers should send notice of any change of address before the 12th of each month; otherwise they are held responsible for magazine, sent to their former address, and no duplicate copies will be sent except on payment of 30 cents for each copy. Send notices to School Science and Mathematics, Mount Morris, Ill., or 2059 East 72nd Place, Chicago.

MANUSCRIPTS. Contributions on Science and Mathematics Teaching are invited. Articles must be written on one side of the sheet only. All illustrations must be drawn or written in jet black on a separate sheet of manuscript. Contributors are requested to write scientific and proper names with particular care. Manuscripts should be sent to the Editor of **School Science and Mathematics, 5517 Cornell Ave., Chicago,** or to the proper departmental Editor. Books and pamphlets for review should be sent to the Editor. To insure insertion in any number, manuscript must be in the editor's *possession not later than the 20th of the second month before* publication.

MISSING NUMBERS will be replaced *free* only when claim is made within thirty days after receipt of the number following.

REPRINTS, if desired, must be ordered in advance of publication. Reprints of leading articles will be printed as ordered, the actual cost (with cover, if desired) to be paid for by the author. Reprints *must* be *paid* for when ordered. The table below shows the *approximate* cost of reprints consisting of plain text or text with line engravings. The actual cost may vary from the figures given and will depend upon the amount of work in re-making the pages into forms, press work, paper, printing, etc.

Number of Copies	100	Extra Hundreds	Number of Copies	100	Extra Hundreds
2 pages	$1.50	$0.25	16 pages	$6.65	$1.35
4 pages	2.10	.45	20 pages	8.70	1.55
8 pages	4.30	.80	Cover, extra	2.75	.45
12 pages	6.00	1.20			

SCHOOL SCIENCE AND MATHEMATICS

PUBLICATION OFFICE **MOUNT MORRIS, ILLINOIS**

Business Office, 2059 72nd Place, Chicago.

Editorial Office, 5517 Cornell Ave., Chicago.

Digitized by Google

15 illustrations, Paul Gooding; "The Making of a Japanese Newspaper," 5 illustrations, Thomas E. Green.

Physical Review, for September; *Ithaca, N. Y.*: $7.00 *per year*, 75 *cents a copy:* "Charcoal Activation," H. Horton Sheldon; "The Effect of Temperature upon the Transmission of Infra-Red Radiation through Various Glasses," George Rosengarten; "The Theory of Linear-Sinoidal Oscillations," Henry G. Cordes; "The K-Characteristic Absorption Frequencies for the Chemical Elements Magnesium to Chromium," Hugo Fricke; "The Audion Oscillator," R. A. Heising; "Application of Electric Currents in the Bunsen Flame," C. W. Heaps.

Popular Astronomy, for October; *Northfield, Minn.*: $4.00 *per year:* "Twenty-Fourth Meeting of the American Astronomical Society," Plate XXI; "The Orthographic Projection of a Sphere," William H. Pickering; "The Design and Construction of a Small Observatory," J. E. G. Yalden; "An Elementary View of Diffraction as Applied to Photographic Photometry" (Concluded), Alice H. Farnsworth; "The First Attempt to Adopt the Gregorian Calendar in England," Roscoe Lamont; "Some Recollections of John A. Brashear," H. B. Rumrill; "First Study of Heavenly Bodies, Mary E. Byrd.

School Review, for September; *University of Chicago Press:* $2.50 *per year*, 30 *cents a copy:* "Classification of Pupils in Ability Groups," James M. Glass; "Training for Citizenship through Practice," Frank G. Pickell; "Uniformity of Teachers' Marks versus Variability," John L. Stewart; "Home Economics Courses and the Higher Institutions of Learning," Agnes F. Morgan.

Scientific Monthly, for October; *Garrison, N. Y.*: $5.00 *per year*, 50 *cents a copy:* "Oceanography and the Sea-Fisheries," A. W. Herdman; "The Internal Constitution of the Stars," A. S. Eddington; "The Scientific" Study of Alloys," C. T. Heycock; "Where Does Zoology Stand?" J. Stanley Gardiner; "The Map of Europe After the War," John McFarlane; "The Economic Condition of Europe After the Napoleonic War," Dr. J. H. Clapham; "The Strength of Materials in Aeroplane Engineering," C. F. Jenkin; "John Tyndall," Arthur Whitmore Smith; "Governmental Research," Dr. George K. Burgess; "The Mathematician, The Farmer and the Weather," Thomas A. Blair; "Ancient Bacteria and the Beginning of Disease," Roy L. Moodie; "Zoology in the A. E. F.," Dr. Robert T. Hance.

Torreya, for July-August; *Brooklyn Botanic Garden, Brooklyn, N. Y.*: $1.00 *per year*, 30 *cents a copy:* "Southern Louisiana from the Car Window," Roland M. Harper; "Value of Nutrient Solutions as Culture Media for Fern Prothallia," E. D. W. Brown; "Two New West Indian Plants," N. L. Britton.

Dietetics for High Schools, by Florence Willard, Washington Irving High School, New York City, and Lucy H. Gillett, Boston. Pages xx+201. 13x19 cm. Cloth, 1920. Macmillan Company, New York.

The crop of books on domestic science has been pretty heavy during the last few years, but none of them have a higher working value than this particular volume. It treats primarily of the kinds of food not for the family alone but for the community. It is the author's belief that the health and welfare of the community depend largely upon the kind of food they consume. The purpose of the book is to teach the best methods and applications of the principles of dietetics to the girls of the high schools. There are twelve chapters. At the end of each chapter is a bibliography of books bearing upon the matter discussed in that chapter. There are many practical problems scattered throughout; valuable tables, too, are presented. A book that every teacher of home economics ought to possess.

C. H. S.

Digitized by Google

School Science and Mathematics does all kinds of printing and engraving. We will be glad to do your work. You will be sure of good work if done from our Plant. Give us a trial

LABORATORY APRONS

Send for Descriptive Circular and Prices

CANVAS PRODUCTS CORP.
SCHOOL DEPT.
Fond du Lac, :: Wis.

Back Numbers Wanted

For the following copies of SCHOOL SCIENCE AND MATHEMATICS in good condition we will pay 25 cents each: May, 1902; April, 1901; February, 1902; April, 1903; April, 1904; January, 1905; June, 1905; May, June, October and November, 1906; April, 1912 and March, 1914.

SCHOOL SCIENCE AND MATHEMATICS
2059 E. 72d Place :: :: :: CHICAGO, ILL.

Laboratory Apparatus and Supplies

We can make immediate delivery on
MICROSCOPES

We prepare
SKELETONS
LANTERN SLIDES
MODELS
MICROSCOPE SLIDES

Laboratory glassware and dissecting instruments for *rush orders*.

We are the Western Branch of the Marine Biological Laboratory of Woods Hole, Mass.

Catalogs are free. Write now.

The General Biological Supply House, Inc.

1177 East 55th St. :: :: :: Chicago, Ill.

Digitized by Google

The Elements of Physics, by R. A. Houston, University of Glasgow. Pages viii+221. 14.5 by 22 cm. Cloth. 1920. $1.90. Longmans, Green and Company, New York City.

This book is written primarily as a text book for schools and beginners in physics. It is more specially prepared for those who are fitting themselves to study medicine. The book is systematically prepared. It does not follow the laboratory method of teaching to any extent. There are 202 figures, many of which have been made new for this volume. The discussion of the matter is clear, to the point, and is a book of authority. It deserves, and doubtless will have, a wide circulation. C. H. S.

Introduction to Vocational Education, by David C. Hill, President of the University of Mexico. Pages xvii+483. 14x19½ cm. Cloth. 1920. Macmillan Company.

It is only recently that educators have turned their attention to vocational education. They now realize that in order to secure the very highest efficiency in academic circles as well as those of a vocational nature the student must be thoroughly understood. There is yet a misunderstanding as to the proper approach to best instruct the individual in vocational training. This text has been prepared by a person who is, probably, better qualified to write on this subject than any other in the country. It is a masterpeice, splendidly written, scientifically correct, full of information, covers the ground thoroughly, and put up in such a manner as to make interesting reading for the ordinary layman. There are thriteen chapters. Major paragraphs begin with bold face type. There are, scattered throughout the book, graphs and tables of statistics. At the end of each chapter, there is a summary of the work presented, likewise a very extended bibliography. It is well indexed, mechanically well made, and is a book which all people interested in vocational training should read and study. C. H. S.

South, by Sir Ernest Shackleton, with 88 pictures and diagrams. Pages xxi+374. Cloth. 1920. Macmillans Company, New York City.

One hardly knows just how to begin a comprehensive review of this most interesting and remarkable account of the latest Antarctic expedition. It sets forth to its readers the tremendous energy, persistency, endurance, ingenuity, general all round unselfishness, good fellowship and all other qualifications that go to make up a true man, of the person who originated and engineered this remarkable undertaking.

The Endurance and Aurora were the two vessels selected which should carry the expedition, the fitting out of which was under the direct supervision of the author of this book. One knowing the man understands that there was nothing lacking in the equipment which should have made the expedition a success. It was no fault of the men comprising its crews or the equipment that the results expected to be attained were not reached. It was the combinations of many of Nature's forces and circumstances, absolutely unforeseen and unexpected, that caused the expedition to fail in many of the aspects and results which the commander hoped to attain.

From the human standpoint it surely does increase one's faith in humanity when we read of the remarkable endurance and ingenuity of Shackleton, Wild, and Stenhouse, and of the extraordinary unselfishness of the unfortunate Spencer-Smith.

Shackleton certainly showed his courage when he attempted relief for his followers by taking passage in a small boat only twenty feet long with five of his men from Elephant Island to South Georgia, a distance of 800 miles over one of the most stormy seas of the south, the temperature of the air being, most of the time, below zero.

This book makes interesting reading for the layman and for people interested in the geography of the polar regions. It is a whole mine of information. It is a book that every one interested in this phase of knowledge should possess. C. H. S.

Digitized by Google

Vol. XX. No. 9 Whole No. 173

DECEMBER, 1920

SCHOOL SCIENCE AND MATHEMATICS

A Journal for All Science and Mathematics Teachers

Founded by C. E. Linebarger

SMITH & TURTON, Publishers

Publication Office, Mount Morris, Illinois

CHICAGO OFFICE, 2059 East 72nd Place, CHICAGO, ILL.

CHARLES H. SMITH
EDITOR
'de Park High School, Chicago

CHARLES M. TURTON
BUSINESS MANAGER
Bowen High School, Chicago

DEPARTMENTAL EDITORS

riculture—Aretas W. Nolan
The University of Illinois, Urbana, Ill.

ronomy—George W. Myers
The University of Chicago

logy, Research in—Homer C. Sampson
The Ohio State University, Columbus

any—Worralo Whitney
Hyde Park High School, Chicago

mistry—Frank B. Wade
Shortridge High School, Indianapolis, Ind.

mistry, Research in—B. S. Hopkins
The University of Illinois, Urbana, Ill.

graphy—William M. Gregory
Normal Training School, Cleveland, Ohio

General Science—Fredric D. Barber
State Normal University, Normal, Ill.

Mathematics—Herbert E. Cobb
Lewis Institute, Chicago

Mathematics Problems—Joseph A. Nyberg
Hyde Park High School, Chicago

Physics—Willis E. Tower
Englewood High School, Chicago

Physics, Research in—Homer L. Dodge
The State University of Oklahoma, at Norman. Representing American Physical Society

Science Questions—Franklin T. Jones
Warner and Swasey Co., Cleveland, Ohio

Zoology—Harold B. Shinn
Schurz High School, Chicago

Published Monthly October to June, Inclusive, at Mount Morris, Illinois
Price, $2.50 Per Year; 30 Cents Per Copy

ered as second-class matter March 1, 1913, at the Post Office at Mount Morris, Illinois, under the Act of March 3, 1879

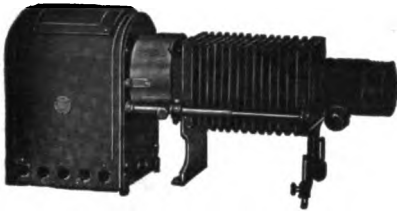
Digitized by Google

"McIntosh Lanterns Are Honest Lanterns."

Lantern Slides of Science

A copy of our Catalogs of science slides was mailed when published to every member of the Central Association. Are you a member? Did you get your copy? Did you keep it?

If not, there is another copy for you if you are interested. Just write us a card and ask for it. No obligation. You'll need it in placing your orders for science slides.



Lanterns from $43.00 up. Opaque and micro projectors, slides and accessories.

McINTOSH STEREOPTICON COMPANY
410 Atlas Block, CHICAGO, ILL.

Back Numbers Wanted

For the following copies of SCHOOL SCIENCE AND MATHEMATICS in good condition we will pay 25 cents each: May, 1902; April, 1901; February, 1902; April, 1903; April, 1904; January, 1905; June, 1905; May, June, October and November, 1906; April, 1912 and March, 1914.

SCHOOL SCIENCE AND MATHEMATICS
2059 E. 72d Place :: :: :: CHICAGO, ILL.

"School Science and Mathematics" bears the same relation to progressive Science and Mathematics Teaching as does the "Iron Age" to the Hardware business. No up-to-date Hardware merchant does without this trade Journal. Every Science and Mathematics teacher should be a subscriber to the professional trade Journal, "School Science and Mathematics."

Please mention School Science and Mathematics when answering Advertisements.

Digitized by Google

SCHOOL SCIENCE AND MATHEMATICS

VOL. XX, NO. 9 DECEMBER, 1920 WHOLE NO. 173

UTILIZATION OF THE CHANCE PROJECT IN SCIENCE TEACHING.

BY FRANK B. WADE,

Shortridge High School, Indianapolis, Indiana.

As Prof. Rolland M. Stewart of Cornell University has so ably pointed out in his article on "The Project as a Method of Teaching," in the October number of this journal, the project method vitalizes instruction. Pupils who are really hot on the trail of a project that appeals to them are very different in their attitude, in their alertness and in their individual achievement from those who are merely attending school. This being the case, does it not behoove us teachers to attempt to use the project method of teaching to as great a degree as our command of the situation will permit? It will be the purpose of this brief paper to try to suggest, by means of an actual concrete experience in teaching, how one may go about making use of the project method. The experience will illustrate two types of project, the first type being that in which the project is suggested by the teacher, the second type is that in which the project has its origin in the desire of some member of the class to know the answer to some question of his own. The latter type of project is usually more successful than the former in arousing interest and stimulating effort on the part of the class.

In the particular case which we are to consider, the class was one in beginning chemistry. For six weeks, the class had been studying, largely by the laboratory method, the nature of oxidation. They had heated several common metals both in the air and under cover of melted borax. They had allowed iron to rust in a confined volume of air and had noticed the one-fifth loss of volume. They had weighed iron wire gauze, heated it, and weighed again, noting the gain in weight. They had burned

Digitized by Google

magnesium, and the teachers of each of seven different sections had oxidized accurately-weighed quantities of magnesium to constant weight and the pupils had seen the wonderful uniformity in the gain percent, as the data was all displayed on the classroom blackboard. By the use of a candle and lamp chimney containing sticks of caustic soda and counterpoised on a balance, the class had noted the gain in weight that attends combustion the products of the combustion having first been identified. Decaying leaf mold had been shown to be giving off carbondioxide. The class had also tested for carbondioxide in the breath and had noted the body temperature. Oxygen had been prepared from mercuric oxide and the history of its discovery had been sketched, including its early peparation by the Chinese from saltpeter, and Scheele's use of Saltpeter to prepare his "fire air."

The above brief outline will give some notion of what subject matter one might expect these pupils to make use of in attacking a project. The whole course, up to this point, had been built on the rather large project of discovering the true nature of tarnishing and rusting of metals, of burning, of decay, and of body combustion, in a word of common oxidation.

The experience which we are to attempt to describe, arose out of a written test or examination which was given at this time, to allow the pupils a chance to see how well they could make use of the knowledge they had acquired. The two principle questions were put in the guise of experiments, one performed before the waiting class by the instructor, the other performed by the members of the class individually. The examination virtually made use of the project method, but the project was advanced by the teacher.

A short candle was floated on a large cork on a dish of water and lighted. Several sticks of caustic soda were exhibited and named, then dissolved in the water in the dish. A large clean beaker was then inverted over the lighted candle and held until the candle had gone out and the sodium hydroxide solution had risen about on-fifth of the way up this beaker. The class was then told to record what had been seen, and to tell what they thought about it.

As it was not this question, but the other one, that led to the pupil project during the class discussion of the test the next day we will pass on with the brief comment that almost without exception, very complete observations resulted from the ex-

Digitized by Google

periment and many pupils were able to connect the results with the one-fifth loss of volume of air that they had met with during the rusting of iron. Most of them correctly interpreted the results, including the absorption of the carbondioxide by the caustic soda solution.

The second problem consisted in giving each pupil a piece of the mixture from a "Sparkler", a well known form of parlor firework. Magnets and lenses were available to each pupil. The pupils were told to examine the material carefully, then to hold it in crucible tongs and light it in a Bunsen flame. After that, they were to write what they had learned about it.

On going over the papers, it was found that nearly every one had detected the magnetic character of both the unburned material and the blue-black product of combustion, and had correctly assumed that the sparklers contained iron filings and yielded magnetic iron oxide. Many pupils also noted the presence of filings of a metal that was whiter than iron and most of them suspected, wrongly, that it was magnesium. (It was really aluminum.) Several suggested that there must be a binder present. The presence of an oxidizing agent, which we rather hoped some few might suspect, was not detected by any pupil. In this connection, it may be mentioned that their only opportunity to know of oxidizing compounds had been by hearsay, when the history of oxygen was sketched, and not by actual contact in the laboratory. Information gotten by the telling method evidently does not stick as well as that obtained at first hand. It is, of course, one of the virtues of the project method, that it supplies much first hand material.

On meeting the class the day after the test, the papers having been gone over in the meantime, the first of the two questions, that dealing with the candle, was discussed and every pupil given a chance to clearly understand to what extent he had succeeded in satisfying expectations and what more he might have done.

The question of the "sparkler" material was next taken up and the observations discussed and the conclusions weighed. When we came to the supposed magnesium filings, a boy, who had made, by the way, about as poor a record on the test as any member of the class, raised his hand and on being recognized, rose to say: "As I was going home last night, I saw them welding a rail with some stuff that had magnesium in it." Now when any member of a class rises with any such remark, there

Digitized by Google

is usually a project, and a real one, too, ready to one's hand, yet on this occasion, the teacher's reaction, at least within his own mind, was to the effect that the subject matter of the boy's project was contained in the very last chapter of the text under "Energy transformations in chemical reactions," and more specifically under "Aluminothermy." In other words, it was out of order at this time with a group of beginners. Fortunately, before the teacher's vocal organs had time to make the fateful announcement, his horsesense came to the rescue and he inquired further as to the character of the mixture used in welding the rails and the mode of using it. The boy was then sent at once to the stock room for some "Thermit" and a little of the mixture was given to every pupil in the class. Lenses and magnets were procured and the black brittle scales were identified as magnetic iron oxide. The bright bits of aluminum were recognized as being similar to those in the "sparkler" of the test. Although reserved for the last chapter of the text, the materials we had before us were precisely those we had just been discussing, either as original materials or as products. Instead of being *out of order*, the subject matter was *very much in order* and *every member of the class wanted to know about it.* Being asked how the men set their mixture on fire, the boy replied "with flashlight powder containing magnesium." He was at once sent for some powdered magnesium and allowed to try to light some, but could not light it either with a match or with burning paper. Neither could he light the "Thermit" in either of those ways.

A question from the instructor at once brought the suggestion from several members of the class that perhaps saltpeter would help by furnishing more oxygen. The review of the theme of oxidizing agents had had its effect. Saltpeter was at hand and the question arose as to how much to use. Right on the blackboard reposed the figures as to the gain in weight of magnesium on oxidation. Somebody saw them and offered the information that the magnesium needed about 66 per cent of its own weight of oxygen. Then arose the question, "How much oxygen can saltpeter give up?" Here the instructor had to help out by stating that it was very nearly one-half oxygen by weight. A balance, sensitive to .001 g., was procured, 100 mg. of magnesium were weighed out and twice 66 mg. of powdered saltpeter added and well mixed on paper. A large crucible was procured, on direction of the boy who had seen the welding

Digitized by Google

performed, the flashlight powder was tested and found to be very quick in its action and the remainder of it was mixed into the surface layer of the crucible full of "Thermit." A bit of magnesium ribbon was suggested as a fuse and a large pan of sand put under the crucible to protect the table top. The front seats were vacated and the fuse lighted. Beautiful fireworks! enormous heat! molten alumina and molten iron! slow-cooling, and then examination of the products. A brief recital of the great chemical attraction of aluminum for oxygen as compared with that of iron and the greater evolution of heat during its oxidation, and then advertising matter of the Metal and Thermit Corporation, which was at hand, was passed and the pictures therein contained taught some of the practical uses of the mixture. About this time the bell rang for the close of the double period.

Now one cannot expect to strike a gold mine like that, with every topic studied, but the thing to do is to be on the alert to use any such project that chances to turn up, even though the subject matter be contained solely in the last chapter of the book. Good judgment must, of course, be used to avoid going too far afield in such discussions. Here is where the project method will succeed or fail, according to whether it is used or misused. There must be skillful guidance, but when properly used, the results are fine. Let us all use it more largely.

SALT WATER AQUARIA FOR THE SCHOOL LABORATORY.

By Myrtle E. Johnson,

High School, Pasadena, California.

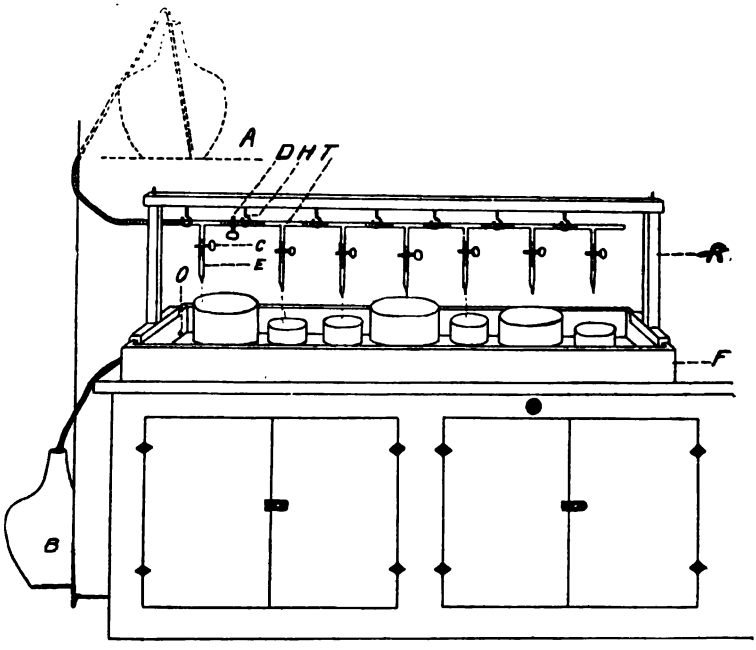
Although the contents of the "pickle jar" may be attractive to the seasoned zoology student, it is rarely so to the young high school pupils, while living animals if exhibited in an attractive way make a strong appeal. The device here described has been found useful for keeping marine animals alive and in good condition in the school laboratory.

In the large salt water aquaria where marine animals are successfully kept it will be noticed that care is taken to aerate the water constantly. Air is usually carried into the tanks along with the incoming stream of water. The apparatus described here is arranged on the same principle though it is so simple that it can be set up at very small cost of time and effort.

As shown in the diagram, the apparatus consists of a tray (F) for the aquarium dishes and a series of tubes (E) which

Digitized by Google

furnish a jet of water to each dish. The tray in this case is 6 feet by 1½ feet and 2 inches deep, of white pine, the joints snugly fitted, and the whole covered with three coats of enamel paint to make it water tight. The rack (R) for the tubing is made from 1x1 inch pine and has brass hooks (H) along the under side of the horizontal piece to hold the glass tubing. Glass T-tubes (T) joined by short pieces of rubber hose rest upon the hooks, a delivery tube (E) drawn out to a capillary point is attached to each T-tube, and spring clips (C and D) serve to cut off the stream of water when desired.



When we get specimens from the beach, we bring home several demijohns of clean sea water besides that which the specimens are in, for the latter is not of much use after the collections have traveled for several hours by automobile. The specimens are taken from the collecting cans as soon as possible and arranged in the dishes, which are filled with clean sea water, as few specimens as possible being put in one dish. A little eel grass and green algae are added to each dish when possible to help in the aeration and to give a pleasing color effect. A ten gallon demijohn of clean sea water is placed on the shelf (A) which in this case, is just inside a doorway in a closet and higher than the rest of the

Digitized by Google

apparatus. The water siphons down through the tubes and leaves the capillary nozzles with enough force to drive considerable air into the water in the dishes. The overflow from the dishes runs to the lower end of the tray and through the outlet (O) into the demijohn (B) which stands on the floor. To make the outlet we insert a three or four inch piece of glass tubing into a hole bored in the tray and pack the chinks with bits of cloth. The enamel paint fills up the remaining holes so that the joint is tight. Rubber tubing is attached to this glass tube. When demijohn (A) is empty, (B) is full, and they may be made to exchange places. If ten gallons of the sea water are run through the siphon two or three times a day it is usually sufficient to keep the creatures in good shape. Some kinds require more aeration than this, while some, such as the sea anemones, can get along with less.

By using a large sized atomizer bulb the siphon may be started with little trouble. Place a clip on the tube at (D), remove the glass tube (E) and the clip (C); attach the collapsed atomizer bulb to the tube at (C) and allow the bulb to expand. As soon as the water reaches (C), replace the clip there and remove clip (D), then remove the bulb and replace the tube (E).

If the animals that die and the food that remains uneaten are promptly removed from the water and if water that becomes cloudy is not allowed to mix with the rest, the aquaria remain attractive for some time. As the water evaporates, distilled water is added to keep the density uniform. The various parts of the apparatus are all detachable so that when it is not in use it is taken apart and stowed away in a small space. Corymorpha, clams, hydroids (*Clytia bakeri*, found growing on the clam *Donax*), shrimps, nudibranchs, crabs, small starfish and sea urchins, and other forms often difficult to keep alive have been kept for two weeks or more in these aquaria and sea anemones may be kept almost indefinitely.

Digitized by Google

A PORTABLE SCIENCE DEMONSTRATION DESK WITH A VERTICAL FILING SYSTEM FOR STORING APPARATUS.

By Chas. W. Finley and Earl R. Glenn,
The Lincoln School of Teachers College, Columbia University, New York.

General science has now become an established course in American high schools,[1] and in a recent report is recommended as a first-year course in those of Great Britain.[2] It frequently happens that because of the crowded conditions in schools this work is taught in rooms poorly fitted for science, in which there is inadequate demonstration materials or storage space for these materials. In many high schools it is the practice to spend most of the money allotted to science equipment on the courses in the upper years, with the result that there is a lack of materials

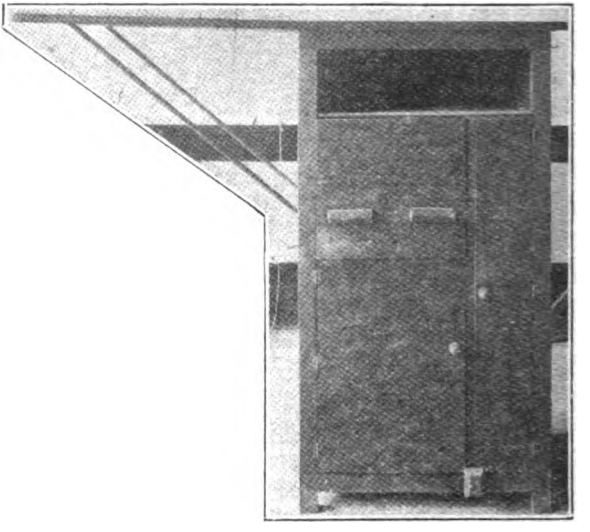


Fig. I.
Preliminary Model of Portable Demonstration Table.

and apparatus in the beginning science courses. When we consider that 150 first-year pupils out of each 316 do not reach the third year[3] it is evident that about half of the high school population is taught in classes inadequately equipped with science materials and apparatus. There seems to be a definite movement in general science teaching to make more use of demon-

[1]Report of N. E. A. Commission on Reorganization of Secondary School Science, 1920, U. S. Bureau of Education.
[2]Natural Science in Education. Report of the Committee on the Position of Natural Science in the Educational System of Great Britain, 1918.
[3]Bonner, H. R., Statistics of State School Systems, 1917-18. Bulletin, 1920, No. 11, Page 31.

Digitized by Google

strations. The knowledge that many teachers in general science have the work added to an already crowded day and that the teaching is often done in rooms poorly equipped for it, has prompted the writers to record a solution to the problem that has resulted in overcoming some of these difficulties and in the saving of much time.

Because of crowded conditions in our school it became imperative to teach a course in general science in a room devoid of gas and flowing water and in which there was no available storage space. For a few weeks it was the daily duty of one of the writers to return borrowed apparatus and materials and procure a new supply from a laboratory two stories removed from the room in which the general science was being taught.

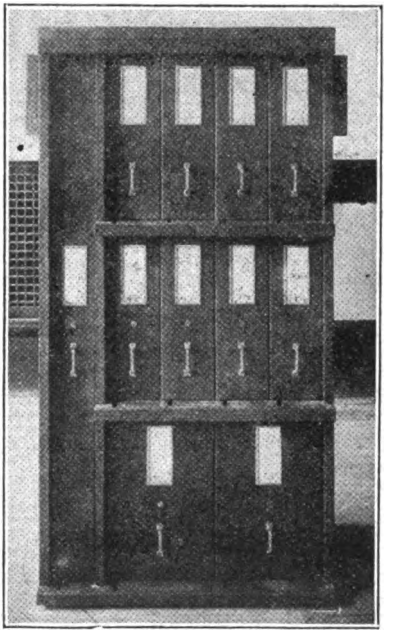


FIG. II.
SCIENCE DEMONSTRATION TABLE AS SEEN FROM INSTRUCTOR'S SIDE.

This routine became a source of much wasted time and continual annoyance to both teachers concerned. It was decided to see whether some plan might not be devised to remedy this difficulty. A list of pieces of apparatus and of materials needed for the year's work was made out and the writers set to work to devise and construct a desk which would serve at the same time as a storage place for the apparatus and a demonstration desk for class use.

Digitized by Google

The first demonstration case was made by us in our own industrial arts shop. The joints were somewhat crude and it is very probable that the desk would not have been accepted as an addition to the furniture in that shop. It served our purpose, however, as in it we were able to store the apparatus and materials needed for the year's work. As is seen in the illustration (Fig. 1) it was equipped with a double top, so hinged that it could be opened, and braced against the side, making a space for demonstration work double the size of that of the regular top.

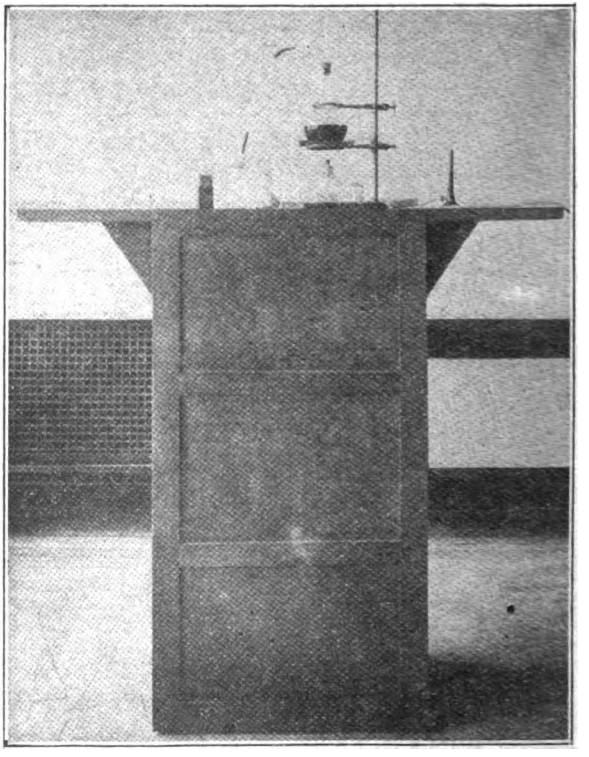


FIG. III.
DEMONSTRATION TABLE AS SEEN BY STUDENTS.

In storing the apparatus and materials needed for the work, all the available space in the desk was taken. This crowded condition made the case somewhat unwieldy and cumbersome. It will be noted that access to the space for storing the longer pieces of apparatus as yard sticks, meter sticks, glass and metal tubing was obtained through a door. It proved to be somewhat annoying to get anything from the back part of this narrow

Digitized by Google

space. So many small pieces were stored in the one drawer that constant effort was required to keep things in order.

A commercial company[4] has devised a vertical filing section which may be pulled the entire length from its case, making the entire contents easily available. The writers designed a desk patterned after the original one made by themselves but modified in such a way as to make use of the vertical filing system. In this new desk the contents of each section may be listed on the index plate as shown in figure two. We have found this index system easily applied to the appartaus lists given in the various science texts. By appending drawer numbers to the articles in the list one is able to save much time in locating apparatus for demonstrations (Fig. 3).

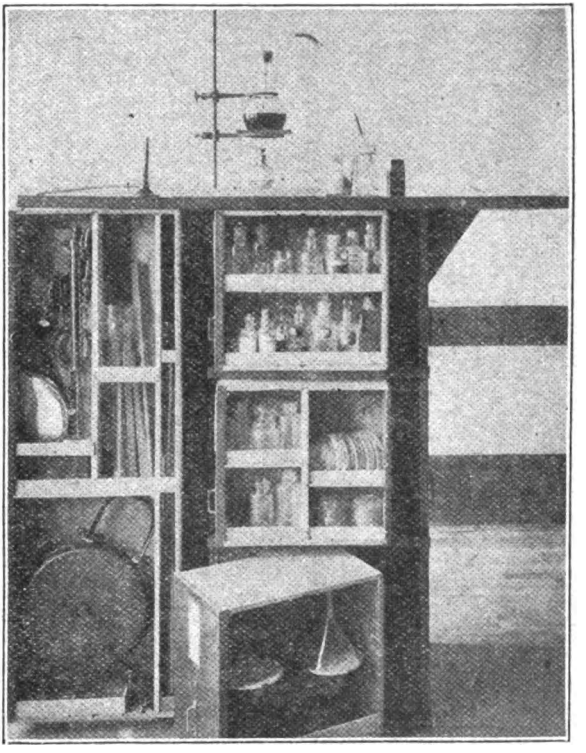


FIG. IV.
A CONVENIENT VERTICAL FILING SYSTEM FOR APPARATUS.

Figure four shows the contents of some of the sections. At the time this photograph was taken, two of the sections were

[4]Schwartz Sectional System, Indianapolis, Indiana.

Digitized by Google

empty and in the remainder there was stored the following articles:

Article	Quantity
A. GENERAL APPARATUS.	
Air pump	1
Alcohol lamp	1
Aquarium jar, small	1
Balloons, rubber	6
Bell jars	1
Bunsen burner	1
Burette clamps	4
Electric buzzers	2
Can, metal, one pint	1
Candles	3
Carbon rods	6
Clamps	6
Compass, magnetic	4
Copper, sheet, square foot	1
Copper wire No. 18, pound	1
Copper wire No. 24, pound	1
Cork borer set	1
Cork stoppers, assorted, dozen	1
Dry cells	5
Electric bells	2
Filter paper, sheets	500
Flower pots	12
Hammer	1
Hand lens	2
Electrolysis apparatus	1
Iron pans	12
Iron wire No. 20, pound	1
Locomotive model	1
Magnets, bar	4
Magnets, U-form	4
Matches, safety, boxes	5
Medicine dropper	1
Meter stick	2
Mercury, pounds	2
Microscope slides and covers	50
Motor, St. Louis form	1
Mortar and pestle	1
Needles, doz.	3
Osmometer	1
Pinchcock	6
Pliers	1
Pulleys, single	2
Pulleys, double	2
Push buttons	6
Ring stands	3
Rubber sheet, sq. ft.	1
Rubber bands, assorted, box	1
Rubber friction tape, roll	1
Rubber stoppers, assorted, lbs.	2
Rubber tubing, gum, ft.	10
Rubber tubing, heavy wall, ft.	10
Rulers	2
Scales, Cenco	1
Screw driver	1
Spring balances	2
Switches, battery	2
Test-tube brush	1
Test-tube holder	1
Test-tube stand	1
Thermometers	2
Tripod, iron	1
Tweezers	1
Weights, metric, set	1
Wire gauze	2
Y-tubes	2
B. GLASSWARE.	
Beakers, 100cc	3
Beakers, 250cc	3
Bottles, wide-mouth	12
Calcium chloride tubes	6
Cylinder, 1 liter	1
Dishes, crystallizing	3
Flasks, 500 cc	2
Funnels	3
Glass tubing, assorted, lbs.	5
Glass plates	12
Graduates, 500cc	1
Petri dishes	6
Test-tubes, assorted, doz.	4
Thistle tubes	2
C. CHEMICALS.	
Alcohol, denatured, pint	1
Ammonium hydroxid, lb.	1
Beeswax, oz.	8
Charcoal, lb.	1
Fehling's solutions, each, 4 oz.	1
Hydrochloric acid, lb.	1
Iodine solution, cc	100
Iron filings, lb.	1
Lime water, oz.	8
Marble, lb.	1
Nitric acid, lb.	1
Paraffin, lb.	1
Potassium nitrate, oz.	8
Sodium hydroxide, lb.	1
Zinc, lb.	1

The firm mentioned above is now listing the case as a "Chemistry Desk." We are anxious however, to have it clearly understood that it was not designed as a chemistry desk, but as one for general science materials for use especially in schools or rooms not well equipped for that type of work, and that our only interest in the desk is the hope that it may be of help to other teachers of general science.

Digitized by Google

A CONVENIENT FORM OF THE NEW SINGING TUBE.

By Charles T. Knipp,

University of Illinois, Urbana, Ill.

The new singing tube recently described by the author[1] may be made to take an exceedingly simple and compact form. The tube need not be large, in fact, for this particular purpose, it works best where the various parts are of moderate dimensions, and when blown as a straight-form tube rather than a branch or L-form as originally designed.

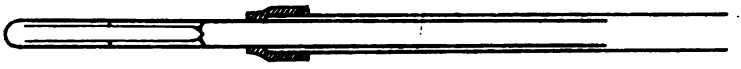


Fig. 2

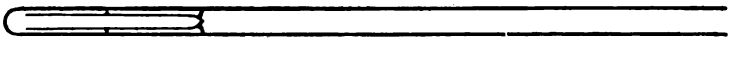


Fig. 1

The form in question is shown half full size in Fig. 1. The outer tube is of heavy wall thickness, about 1 mm., while the inserted test tube is made out of the thinnest walled tubing that is procurable. The relative length of the inner tube is as shown in the figure. Its dimensions and the manner in which it is mounted within the outer tube are of the greatest importance. It has been found best to support the inner tube by three small glass projections symmetrically placed at its lower end. These are later fused to the outer tube as shown. To lessen the likelihood of the inner tube being broken from its rather frail support by rough handling three small additional projections are fused to the wall of the inner tube at its midpoint. These projections are ground off until the inner tube will just slip into the outer casing. The inner tube must also be perfectly centered. It is well to shrink the outer tube down onto these projections by returning the tube for a moment to the oxygen blast. This latter operation also affords an opportunity for exactly centering the open end of the test tube.

Finally, the outer tube is now closed as shown in Fig. 1. The successful operation of this singing tube depends upon the relative lengths of the inner and outer tubes; upon the annular area between the test tube and the outer casing; and, to a less extent, upon the wall thickness of the inner tube, and also upon the volume enclosed above the lip or open end of the inner tube.

By constructing a second tube, which is exactly similar to that shown in Fig. 1, except that it is a few centimeters shorter,

[1] A Possible Standard of Sound, Phys. Rev. N. S., XII, 6, p. 491, Dec. 1918; A Study of Energy of, Ibid XV, 2, p 156, Feb. 1920; I, Study of Operating Conditions, II, Study of Wave-Form, Ibid, XV, 3, p 244, Mar. 1920; Further Developments Relative to the New Singing Tube, Ibid, XV, 4, p 336, Apr. 1920.

Digitized by Google

and which is provided with a sliding extension (as shown in Fig. 2), the phenomenon of beats can be beautifully shown. The tips of the two singing tubes are heated simultaneously over a bunsen burner by holding the tubes one in each hand. By adjusting the extension the frequency of the beats may be changed at will. The two tubes are easily tuned. The tones emitted and the beats produced are readily audible over a large room. These tubes thus form a convenient companion set, and the phenomena that may be exhibited by them are both interesting and instructive. They are blown of pyrex glass.

THE EDUCATIONAL BASIS FOR JUNIOR AGRICULTURAL ORGANIZATIONS AND HOME PROJECT WORK.

By Jas. H. Greene,

University of Illinois, Urbana, Ill.

Man in general is interested in two things, *today* and *tomorrow*. *Yesterday* interests him but little in comparison with these two. As he grows older he sometimes becomes more interested in *yesterday* and *tomorrow* and less in *today*. But when he is of high school age while he makes the most of today, he likewise is thinking of *tomorrow*. What will it bring him of fame and fortune? Shall he cast his lot with the doctor or lawyer, the engineer or farmer?

Meanwhile the days are not long enough for the things he wants to do. All out-of-doors beckons him. The athletic teams, the growing plants and animals, books, his companions, his family, all present problems and activities of interest. He is living his life *today* and is loath to believe any who would tell him that this is merely preparation for *tomorrow*.

But he will listen to any proposition that seems to him to connect the two. That is one of the reasons that club work appeals to young people. The contact with livestock *their very own*, the responsibility for its care and management, the association with clubmates and leaders, the activities of clubs, hikes, excursions, exhibits and demonstrations, all of these activities appeal to them as being things of importance, *today*. But they are likewise of tremendous significance for *tomorrow*. These young people, who are now telling their stories of achievement in the club section of the Breeders' Gazette, will be the ones whose baby beef and hog feeding and breeding operations will be described in other sections of coming volumes of this paper.

Life—and life and education are practically synonymous

Digitized by Google

terms—is after all a matter of growth. The activity of today helps in successfully undertaking the slightly larger job of tomorrow. There is an old legend of a Roman general whose army had been defeated for the first time by an army of barbarians. The soldiers were discouraged and the old warrior wished to show them that final success is but the sum total of a number of small defeats and victories. He caused two horses to be brought out before the army. One was a magnificent animal, powerful in every line and muscle; the other was a mere bag of bones and was so weak that he could hardly stand. Then the general called out the most powerful man in the army, a magnificent fellow, over six feet in height and well muscled. He also produced a small, weak, mild-mannered little man, with no physique and unaccustomed to feats of strength.

He commanded the powerful soldier to pull out the hairs in the tail of the weak horse, *all at one time.* The soldier took a good grip on the tail and dragged the poor animal all over the ground, *but he could not pull out the hairs.* The little man was then ordered to pull out the hairs in the tail of the powerful horse, *one by one.* In a short time the tail was almost bare. It is recorded that the army took the lesson to heart and ultimately triumphed over the barbarians.

In clubwork young people tackle a real job of just the right degree of difficulty and after completing that, go on to one involving more thinking and more responsibility. A club enterprise is like a single hair in the tail, which we might call the big business of agriculture. The things necessary to make that enterprise a success are learned. Completing a series of projects or enterprises is like pulling out the hairs one by one.

Down in the little city of Effingham, Illinois, St. Anthony's Educationalists, who had been enthusiastic "clubbers" for a number of years, organized a "Thousand Dollar Tomato Club" last year. They secured a tract of about eight acres and carefully laid their plans. Heavy and prolonged rains delayed the setting out of plants and a luxuriant growth of weeds made another plowing necessary. Time was short and the plowing was done by a tractor, thus incurring further expense. Continued dry weather made cultivation difficult and delayed the maturing of the crop. Marketing time found a small crop matured but a high local price. The crop was already sold, however, to a canning factory at a lower price and the club members respected their agreement. Then came a strong local demand for green

Digitized by Google

tomatoes for pickles. Hope revived in the breasts of the young agriculturalists, but alas a sugar shortage prevented the club from realizing anything in this way. At the end of the season part of the "thousand dollars" was on the wrong side of the ledger and the club resorted to entertainments to pay for their "agricultural flyer." But the story is to be continued. This year the "Thousand Dollar Tomato Club" is again at work and has added a small commercial canning outfit to its equipment. When the time comes to harvest the crop, the club expects to be independent of immediate market conditions. It has capitalized its difficulties and is "pulling out the hairs one by one." Though its receipts may not reach the thousand dollar mark this year, the club eventually will attain its goal and ultimately win it. It matters not what calling in life is ultimately followed; whether medicine, law, engineering or business, somewhere that occupation will touch agriculture, and the first-hand information which is acquired in running a farming enterprise will prove of service.

The boy or man who prefers to lead a hermit's life is an exception. The success of athletic teams, debating societies, class or school parties, and picnics depends upon organized effort. One likes to share his pleasures and his responsibilities with his friends. Riley gives a picture of this in his poem, "The Impetuous Resolve:"

When little Dickie Swope's a man,
  He's go' to be a sailor;
An' little Hamey Tincher, he's
  A-go' to be a tailor:
Bud Mitchell, he's a-go' to be
  A stylish carriage-maker;
An' when *I* grow a grea' big man,
  I'm go' to be a baker!

An' Dick'll buy his sailor-suit
  O'Hame; and Hame'll take it
An' buy as fine a double-rigg
  As ever Bud can make it;
An' nen all three'll drive roun' fer me,
  An' we'll drive off togevver,
A slingin' pie-crust 'long the road
  Ferever an' ferever!

The organization side of club work is of great future importance. Everywhere, organizations are springing up. Do

Digitized by Google

we have a grievance? Organize all others with similar grievances and secure our rights. Unfortunately, many organizations are being wrecked on the rocks of greed and selfishness and all because there are only a few men in these organizations who know how to conduct business. These leaders are playing upon the ignorance of the mass of the membership and leading them astray. We cannot afford to belong to an organization and lend our support to it unless we understand the machinery and know how to keep it headed straight. The farmer, it can be said, has seldom, if ever, lost his head in his organized demands upon society. In many cases, he has held a brief for society in general as against a particular group of middlemen. For this reason, it is all the more important that he should know how to work in an organization.

There are two other important things to be considered in connection with organizations. First, successful leaders in any organization must know how to meet men and deal with them. This training can be acquired only through experience, although of course, some individuals have more native ability along this line than others. Second, no organization can long succeed which does not take into account its responsibilities to other individuals. A sheep club or pig club, which planned deliberately to make use of its organization to market its stock dishonestly, would not long succeed even if it could "put over" the first "crooked deal."

If education is "growth" and is not "preparation for life" but *life itself*, as one educator has expressed it, the materials of education should be those life situations which will develop habits, skill, appreciation and ideals of the right sort. Necessarily the size and scope of these life situations must be reduced to fit the mental and physical stature of young people. When these life situations are those that are a part of the normal interests of healthy, wholesome individuals it no longer becomes a problem for the teacher to get these young people to enter whole-heartedly into the activities in question.

Club organizations and home projects provide such life situations. Club leaders and vocational agricultural teachers have the responsibility of guiding these activities of *today* in such a way that they will enlist the whole-hearted participation of these young people and will build for *tomorrow*.

Digitized by Google

THE DECAY OF MOUNTAINS AND THE FORMATION OF SOILS

By Lyman C. Wooster
State Normal School, Emporia, Kansas.

1. Soils.

Soils are indispensable to all forms of life, for without them land plants could not exist on the face of the earth and without land vegetation all forms of land life must live on the products of the rivers, lakes and ocean or must perish, since all animals feed directly or indirectly on plants.

As soils are products, chiefly, of rock decay, the two problems are closely linked together and must be solved as one. Study of soils should come first as the special phases of rock decay to be studied in this paper are determined by soil composition.

The chief physical components of the soil are as follows:

Bowlders, 3 feet to 3 inches.
Gravel, 3 inches to 1-25th of an inch.
Sand, 1-25th of an inch to 1-500th of an inch.
Silt, 1-500th of an inch to 1-5,000th of an inch.
Clay, 1-5,000th of an inch to 1-250,000th of an inch.
Humus, of varying size.

All these components are found in most soils but in varying proportions, so the name is determined by the dominant component. These soils or loams with their characteristic crop or crops are:

Stony loam—forests.
Gravelly loam—berry bushes.
Sandy loam—potatoes and melons.
Silt loam—alfalfa and corn.
Clay loam—wheat and pasturage.
Humus loam—rice and cranberries.

These soil components are valueless for crops when alone, but serve each to supplement the others when combined so as to meet the needs of the plants.

Held in the interspaces of these loams are various substances, held in solution by water, that are necessary to green plants in food-making. These substances may be placed in two groups, as follows:

Food materials and elements.
Water—H and O
Carbon dioxide—C
The saltpeters—N
Gypsum—S
Fosfate rock—P
Accessory food materials.
Soluble compounds of potassium
Soluble compounds of iron
Soluble compound of calcium
Common salt
Silica

How these accessory food materials are used by the plants

Digitized by Google

is not known, but the biologist has determined that green plants cannot make sugar unless potassium is present, nor chlorophyl unless iron is present, yet neither metal is found in these products.

These food materials are present in sufficient quantities in the loams for the various crops unless the balance has been destroyed by unwise farming. In the latter case they must be returned or the yield per acre will certainly be diminished. Some of these materials are yielded, with the soil components, in the decay of mountains or of the sedimentary rocks of the plains, part through the decay of plants and animals or from the excreta of the latter and part from the atmosphere. Knowing these sources of these food materials the farmer must use his power to determine which is lacking and supply it.

Taking next the decay of rocks we shall find that the problem must be divided into two parts, the second depending for its solution on a right understanding of the first part.

2. Rock Decay in Mountains.

"As durable as the everlasting hills" is not accepted by the geologist as meaning a great duration, for of all regions of the earth the mountains are most subject to change, and are most quickly removed through erosion and carried to the sea.

The common rocks of mountain ranges are granite, gneiss, mica schist and hornblende schist. The minerals composing these rocks are quartz, feldspar, mica, and hornblende. Of these minerals feldspar is most abundant and is quickest to decay. With feldspar gone the quartz is rolled down the mountain slopes by gravity, rains and rivers to the sea-shore where it is reduced to sand by the waves. The mica, small in amount, generally goes with the sand. The hornblende decays with the feldspar.

As one climbs up and down the mountain ridges about Estes Park, Colorado, he ceases to wonder how the glaciers of North America managed to pick up and push to the lowlands the millions of tons of boulders and finer material which cover the surface of the United States from Cape Cod to Puget Sound. The massive moraines of Estes Park could be duplicated several times over should glaciers again clean the neighboring peaks and ridges of the Park of loose rock material.

Geologists name the outer eight or ten miles of the earth the zone of fracture because the rocks in this zone break when flexed or folded; and the deeper parts of the earth, the zone of flowage, because the rocks here are so hot and are under such

Digitized by Google

great pressure that they flow under local stresses as in mountan making.

Geologists say further that the interior of the earth is shrinking from loss of energy and that the surface zone, in accommodating itself to a smaller interior, is forced into anticlines and synclines by lateral pressure. These wrinkles in the face of mother earth are the mountains with their peaks and ridges carved from the great ridges. But flexures of the rock in the zone of fracture must result in its being deeply fissured, thus exposing the rocks of this zone to the solvent action of water, the rending of frost and the weathering action of the atmosphere.

The most vulnerable minerals in rock decay are the feldspars and hornblende, and the chief agents in mineral decomposition are water, carbonic acid and silicic acid. Common feldspar, the feldspar of the granites, gniesses and schists, is a double silicate of aluminum and potassium. The carbonic acid of rain-water removes the potassium, combines with it and makes potassium carbonate, one of the ingredients of the alkali of clay soils. On meeting nitric acid the potassium carbonate becomes potassium nitrate or saltpeter, one of the necessary food materials. The remainder of the feldspar is kaolin, the chief ingredient of clay, and colloidal silicic acid. As all know, clay is the chief component of most soils between and near mountain ranges, carried there by the rains and rivers.

More than one-half of the thickness of the strata penetrated by deep wells in Kansas is clay rock or shale. The clay of this shale came from the Ozarks of Missouri, the Arbuckle and Wichita mountains of Oklahoma and from the Rocky Mountains of Colorado.

The colloidal silicic acid, released when the carbonic acid combined with the potassium of feldspar, is part of it carried into the rivers, lakes and ocean where it yields silica to the various plants and animals that use this substance for their skeletons, notably diatoms, rhizopods and sponges. The remainder of the acid descends with the water to the zone of cementation and either converts the sandstone into quartzites or descends still further to the deeper, hotter parts of the zone and changes the carbonates into silicates. The carbonic acid released then ascends to the zone of weathering and sets free more silicic acid which then descends to the zone of cementation, doing work as before.

In a similar way the soda-lime or plagioclase feldspars of the lavas and other extrusive materials are decomposed in the zone

Digitized by Google

of weathering by carbonic acid with the production of sodium carbonate and calcium bicarbonate and kaolin and the liberation of silicic acid. The sodium carbonate may be changed to common salt on encountering chlorine or to Chili saltpeter on meeting nitric acid or it may be laid down with the kaolin in beds of clay and be black alkali so destructive to crops. The calcium bicarbonate is the "lime" of hard water. When freed of half its carbonic acid it serves as excellent material for the skeletons of water plants and animals.

The intrusive basic rocks such as gabbros and diorites also contain the plagioclase feldspars. These consist of silicic acid combined with aluminum, sodium and calcium and meet the fate described in the preceding paragraph. Associated with the plagioclase feldspars in these basic extrusives and intrusives are augite, hornblende and various compounds of iron. Carbonic acid reduces all these minerals in the zone of weathering to carbonates and simpler silicates, such as kaolin.

Summary: The minerals composing the granites, gabros and lavas are reduced in the zone of weathering to kaolin, potassium carbonate, sodium carbonate, calcium bi-carbonate, magnesium bi-carbonate and iron bi-carbonate. In time, or more rapidly under the influence of heat, carbon dioxide leaves the iron bi-carbonate and the latter becomes the red or brown oxide of iron so evident in brick and in red sandstone.

Brought up from the zone of cementation where silicic acid is supreme by the mountain-making forces to the zone of weathering where carbonic acid rules, the granites, gabbros and diorites and basic lavas slowly yield part of their basic metals to carbonic acid with the result that the mountains are brought low and the tributary rivers are loaded with sediments for transportation to lake basin or continental margin.

Not all the results of weathering reach the lake basins or the marginal continental shelf at once but much of it lingers on the way to serve as soil and subsoil for the use of vegetation.

3. The Decay of Fragmental Sedimentary Rocks.

The boulders, gravel, sand, silt and clay that reach some interior lake or sea or the continental shelf on the borders of the ocean become cemented and compacted in the course of milleniums and are then termed by the geologist conglomerates, sandstones and shales. In a silimiar way the coral reefs and shell beds are beaten and ground by the waves of the sea till fine or coarse grained limestone results.

Digitized by Google

Then the sea-bed and the continental shelf are lifted above the sea level by the slow and long continued elevation of the earth's crust by the same forces that caused the ranges of mountains to come up along the borders of the sea, and we have the great plains and plateaus between the mountain ranges of our continents.

As in the case of mountains the water, frost and carbonic acid attack this new-made land converting the sandstones, shales and limestones into loams for the use of vegetation.

The clay of shale furnishes its own cement. The cements of sandstone are clay, calcite (calcium carbonate), ferric ozide and silica. Rainwater slowly changes the shale back into clay, rainwater and carbonic acid remove the cements of sandstones, excepting silica, and the sandy loams good for potatoes and watermelons show the nature of the underlying rock. Rainwater and carbonic acid may remove all the calcite of limestone leaving merely impurities such as clay, or they may take away first the cement leaving for a time the fragments of corals and shells for the geologist to carry away for his collections.

The cement becomes calcium bicarbonate and flows with the water to the sea. In the sea the corals reject half of the carbonic acid and use the calcium carbonate for their skeletons. In the course of time the skeletons are reduced by the waves to limestone mud and this soon becomes limestone, completing the cycle when the sea becomes dry land.

This accounts for the sandy, silt and clay loams through the weathering of sandstone, shale and limestone by the action of rainwater and carbonic acid. But what is the origin of the stony, gravelly and humus loams?

It is now known that a broad ice sheet shoved southward from Canada as far as the Missouri and Ohio rivers, Northern Pennsylvania and New Jersey and Long Island bringing enormous quantities of pulverized limestone, sandstone and shale and billions of tons of boulders and gravel composed of all kinds of rock over which the ice sheet passed and left the load spread out where the ice melted.

Elsewhere in Eastern Kansas the gravel is derived from the chert (flint) concretions of the decaying limestones. Humus loam receives its organic matter chiefly from the decay of the leaves and roots of plants that have grown in the soil where the humus is found. This is a fortunate distribution of humus for no soil is fertile without humus and the included bacteria.

Digitized by Google

FIELD TRIPS—NOTES ON MANAGING.

By Ellis C. Persing,
Glenville High School, Cleveland, Ohio.

The topic for consideration is not one of my own choosing but one which I am glad to discuss because I believe that it is one of the vital problems in the teaching of science, especially in the teaching of biological science.

Since the relation of recitation, laboratory, and field is so close, a discussion of one includes a consideration of the other two. Much criticism has been directed against science teaching because of bad methods and inefficiency in field and laboratory work.

The natural laboratory is the great out-of-doors, but since conditions will not always permit us to do the work in the field, it must be done in the schoolroom. Sometimes, however, it is an advantage to do the work indoors with the necessary equipment and protected from the weather. I have known teachers who consider field work as something separate and apart from the regular work of the course. The result is that pupils soon acquire the same idea and look upon a field trip as a picnic and go for no other reason than to have a good time. On the other hand, pupils may acquire a feeling of dread for field work because the work is not motivated and unnecessary notes are required.

The latest data[1] available indicates an increased interest in field work on the part of the teachers with an encouraging increase in the number of schools offering this phase of the work in connection with biological science.

The content and nature of the course will affect the field work. Courses in biology and botany are rapidly being reorganized to suit the needs and follow the interests of the pupils rather than to present the subject in a logical way. Morphology, which was so much emphasized a few years ago, is being replaced by phases of the biological subjects which make applications to the life of the pupil and the community.

To be of value in proportion to the time spent, I am convinced that a trip must have a definite purpose. I can not agree with those who believe that the class should go to study plants and animals as they may happen to come to their attention. The purpose may be stated in the form of a problem or a number of problems. These problems may have been suggested by the

[1]Downing, Elliot R., "Some Data Regarding the Teaching of Zoology in Secondary Schools." School Science and Mathematics, Vol. XV, pp. 36-43.

Digitized by Google

pupils and teacher in the class discussions previous to the trip and will then be attacked with interest by the pupils. This lack of motivation is easily noticed in the field or laboratory work, which becomes mere drudgery on the part of the pupil and gives a feeling of relief to the pupils when the period has closed.

If possible, the teacher should go over the field before the trip is made with the class. This will avoid needless confusion and with the wise teacher will aid in suggesting problems which can be studied on the trip.

It has been my experience that unless pupils are required to record their observation by means of drawings or words, they are liable not to see with exactness. This does not mean that pupils must make artistic drawings, as crude sketches many times may indicate the facts in a scientific manner.

A great deal of time may, however, be wasted by requiring pupils to spend one-half or more of the field or laboratory period in writing unnecessary directions, which means that very little time will be available for the study of the real problems.

The specimen sheet for a field trip has been used by the writer for a number of years. It is only suggestive for the pupil and should not be handed to him before the discussion has led up to these problems or similar ones. Without the proper motivation and the personality of the teacher it would be useless.

FIELD TRIP.

No..... Name.....

Time..... Place.....

.....

Problem.

1. To identify some of the common weeds.
2. To make a weed survey of some vacant lot or the roadside.
3. To collect material to be used later in the work.

Directions and Observations.

1. (a) Take some weed manual with you on the trip and use to help you in finding the name of the weed.
   (b) Record the names of the weeds identified on the back of this sheet.
2. (a) Determine the number of different kinds of weeds on the lot agreed upon for that purpose and record.
   (b) Calculate the number of weeds per square foot on the lot and record.
3. Collect any material that may be of use to the class later in the work such as *fruits*, *seeds*, *leaves*, etc.
4. Have a good time but do not forget that we have some work to do.
5. When you return from the trip carefully sort all materials collected, label and set aside in some place assigned to you for that purpose.

Digitized by Google

Inference.

1. What structures and characteristics enabled you to identify the weeds?
2. How does the number of kinds and the number per square foot compare with what you expected to find?

Remarks.

Record any questions which were not fully answered in the field, and any other question for class discussion.

A laboratory manual should be used in somewhat the same way in which a catalogue or guide would be used in visiting one of the large museums. The museum catalogue directs our study, leads us to make certain observations and supplies facts necessary for us to make our own generalizations. If used in this way a sheet of printed directions or a manual will be a great help to the pupils. The teacher can then work with the smaller group or individuals as the occasion may require and at the same time the other pupils will have a guide by which they can go on with the work until the teacher may find time to help them.

Field or laboratory work may consist of individual projects instead of group work. The pupil may be interested in some phase of biological science as collecting to complete the life history of some insect, growing a home garden, collecting material for the aquarium or working on some other problem of special local interest. The teacher, of course, should make suggestions and help as the occasion may demand. A certain amount of credit is given for this work, consistent with the system of grading.

As a means of accomplishing the laboratory and field work, a growing room or greenhouse is necessary, with a small plot of ground on the school lot, where plants can be kept for experimental purposes. Animals should be studied in the field whenever possible, but much time may be saved by keeping some animals, such as insects, in the laboratory under as nearly normal conditions as possible where observations may be made daily. Local conditions determine just what equipment is necessary; but the expence for this scheme is not great. In laboratories which do not already have growing rooms, changes necessary to make such rooms could easily be made. The breeding cages and aquaria can be made at a small cost with the help of pupils who are usually glad to aid in such work.

In the city a number of difficulties at once arise. One is to find a suitable place for the trip. It is not always possible to find an ideal place for this work but in many cases a trip can be made to a nearby vacant lot or to a city park. It is by no means

Digitized by Google

necessary to make a trip of ten or fifteen miles to the country when much available material may be found near to the school.

A trip to some large greenhouse may be taken to give an opportunity to study a number of problems relating to plants such as plant culture, how plants can be used in and about the home and to gather data for many other problems.

Another kind of trip, and one which I consider of as much importance as any that is taken during the year, is the one made to the laboratories of the City Health Department. Pupils make this trip about the time the topic of bacteria and disease is studied. This adds interest to the class work and shows the practical application of the subject to human welfare.

When two periods are not available in the regular schedule for this work, arrangements can sometimes be made with the principal for the pupils to take a half day once a semester for such work. A half day is necessary when a long trip is taken. The time required to travel the long distance to country or field warrants more than forty-five minutes to one hour in the field for actual work. In some cases the trip can be made after school or on Saturday, according to the nature of the trip and the arrangement of the schedule.

It is an advantage to organize the classes into a Science Club. The pupils then take an active part in planning the trips and working on certain projects, such as making collections of various kinds for exhibition or classroom use, or taking a bird census.

With the reorganization of education during war times we are led to consider our courses of study with a view to eliminating non-essentials. If field work is essential, and I firmly believe it is, then let us make it of such a nature that it commands the respect of pupils and administrative officers. It is our duty as teachers to pause long enough to consider our methods, whether they are the means by which we can accomplish the best results and, if not, to revise them at once.

With definite problems, proper motivation and work carefully planned, the field trip and laboratory work should cause little trouble for the teacher and be a great help to the pupils.

Digitized by Google

THE APPLICATION OF ENGINEERING AND SCIENCE IN SHIPBUILDING.

By George D. Roalfe,

702 Ferguson Building, Los Angeles, Calif.

As this paper is to be a discussion of various phases of ship construction, it might be well to begin with the derivation of the word "ship." Translated literally from the Greek it means a scoop. The most probable inference that can be drawn from this is that the boat or ship that was known to the earlier Greek writers had the form of a hollowed out log. In literature mention is made of ships by Homer and Virgil as well as by earlier writers. The word that we use today being of Greek origin depicted the boat of the period though conclusive evidence exists that the water borne craft had large use long before this time. The development of the ship is the result of constant improvements which can be divided into seven stages.

1. Rafts or bundles of brush or reeds that gave sufficient buoyancy
2. Dugouts or logs that had been hollowed out either by the use of fire or crude tools.
3. Canoes composed of bark or skins sewed together.
4. Canoes built of pieces of wood or reeds firmly fastened or woven together.
5. Vessels constructed of wooden planks with members that acted as stiffeners also with at least partial decks.
6. Vessels constructed with a complete framework which largely took up all the stresses, the wooden covering on the hull being simply designed to act as a shell to keep the water out.
7. Vessels composed of steel.

Well authenticated descriptions exist of some of the earlier types. Probably the first advance from a simple raft was the addition of a raised platform on which the passengers or cargo being transported could be placed and keep dry. In the light of present day construction this expedient seems very crude but was a marked advance at that time. Similarly sides were raised on rafts used in warfare, first as a protection from the missiles of the enemy. This was the predecessor of the portion of the ship now known as the gunwale, and for each and every portion of a modern ship such a historical tracing could be drawn. That development has occurred concurrently along almost similar lines in different portions of the world is well known. In some cases this has occurred entirely independently, giving a wonderful illustration to the fact that most of the benefits of any civilization are simply the answers to desires, and are possible of realization only by the application of scientific principles. That this application may be made without a thorough

Digitized by Google

understanding of laws at work is not only conceivable but is demonstrated all around us. The chief difference between the primitive shipbuilder and the one of the present time is that the primitive man followed scientific principles much in the same manner as a child learns to keep away from a fire for fear of getting burnt, while the one of today searches for the underlying laws and then guides his work in accordance with them. This in fact, gives us a good definition of pure engineering which in a few words is the prosecution of constructive work by the aid of and in complete accord with the laws of nature.

The small boat with an outrigger to assist in maintaining its equilibrium is still found in the Islands of the South Sea and seems to be typical of development in these parts. The legends of the Phoenicians and the Egyptians bear evidence that mariners from both of these countries had visited portions of the South Seas and the absence of boats equipped with outriggers in the case of both Egypt and Phoenicia would seem to indicate that they had developed at the time of these visits superior boat types of their own.

The earliest Egyptian records that describe boats are given a date of about 3000 B. C. and the boats there described must have been of some size as they were powered by many rowers. When the ultimate power that could be produced by one set of rowers had been obtained types were developed using two and three banks of oars. These are known as biremes and triremes. Where credit should be placed for the development of biremes and triremes is uncertain except that it lies between the Egyptians and the Phoenicians. It is known, however, that the art of navigation was greatly advanced by the Phoenicians though unfortunately information regarding that progress has come to us through Assyrian sources. The Greeks developed a large undecked galley type which was stiffened with hogging cables running full length and supported over check timbers amidship.

Up to the time of Christ the chief forces behind ship construction had been military ambition and conquest. Despite this, some nations such as Phoenicia were principally traders. Early in the Christian Era the pirates who had infested the Mediterranean Sea were largely subdued and much commerce resulted. During this period all types of sails and rigging showed marked improvement. In passing it might be well to mention several other periods that have been particularly active in maritime

Digitized by Google

history. While it is true that the inhabitants of the Scandinavian peninsula have always been sea-faring people and have done much along these lines they have not been a very large factor during the last few centuries. The early Norse seamen are believed to have visited America in the Northern latitudes many years prior to its discovery by Columbus and are known to have visited Iceland and other portions of the Arctic Regions.

About the close of the twelfth century the Crusaders started for Palestine and as a result there was a big boom in shipping, particularly in England. From this time up to the discovery of America much interest was taken in water trading. After the discovery of America three countries became very keen if not altogether bitter competitors in trade namely Holland, Spain and England. In the sixteenth century Spain who was then in her zenith of power decided to build a large battle fleet and to subdue England as well as all her other trade competitors. Therefore in 1588 the great Spanish Armada set sail for the North to make Spain the complete mistress of the sea. It numbered all told 132 vessels the largest of which was of 1300 tons burden while 30 were under 100 tons each. They were most ingloriously defeated with the aid of the elements and this battle led to England becoming the mistress of the sea, which position she has held without much opposition except the competition of America in the time of the Clipper ships and today and Germany. The shipbuilding activities of the United States during the war greatly increased our tonnage at a time when England was having difficulty holding her own.

In 1777 an item appeared in the London Gazette announcing the launching of an all iron boat on the River Foss, Yorkshire, England. Shortly after this the substitution of iron for wood became quite general for portions of the ship. As is true in any departure from current practice much adverse criticism was brought forth and the contentions of the critics can be summarized under four heads.

1. The weight of iron being so far in excess of that of wood would make it impracticable of use. The fallacy in this statement is readily discernible by everyone today though for a long time it held considerable weight. If the above contentions were true, we would find the largest ships constructed of wood rather than of steel which is the only practical material in present use.

2. In the event of grounding or collision that an iron ship would stand less abuse than one constructed of wood. Experi-

Digitized by Google

ence has shown that this is not the case. Steel is the more resilient material and as a result will stand sudden shocks with greater freedom from danger than wood under the same conditions.

3. That an iron ship would corrode and foul more rapidly than would the wooden one. This argument had really more weight than the two preceding ones, but steel ships today are kept in shape with little if any more trouble than the wooden ones.

4. Owing to the magnetic properties of iron the action of the compass would be interfered with, rendering navigation by its use impossible. In 1839 Sir G. B. Airy read before the London Society a paper in which he described some experiments and made suggestions as to methods by which these troubles could be overcome. The methods now in use are simply modifications of the suggestions which he made at that time.

Steel ship construction as we know it today was first introduced about 1870. The improved methods used in this type of construction will be described later on.

The mechanical or power side of ship construction has shown, similarly, wonderful development along with that of hull construction. There are three types of energy that have been applied to ship propulsion. These are manual, sail, and mechanical. The manual will include poling, paddling, and rowing. The sail appeared in very early examples, in the first cases being in the nature of an auxiliary to rowers. The highest example of a sailing ship is found in the Yankee Clipper Ship that is said to have shown his heels to all the world.

Even while the Clipper Ship was at its height, steam propulsion was making its appearance. All the earliest installations were of the single cylinder type. In 1854 John Elder successfully used a compound engine on a boiler pressure of 42 pounds. After several trials which had proved disappointing largely on account of the low steam pressure employed, Dr. A. C. Kirk introduced in 1862 a triple expansion three crank marine engine.

For this installation he had raised the boiler pressure to 125 pounds marking the beginning of the movement toward high pressure boilers and in a special craft we now find pressures of 300 pounds and upward. Another development in power machinery was the introduction of the steam turbine. Many advantages are claimed for it over the reciprocating engine but there are several disadvantages that apply particularly to marine installations. The very latest development in power units is what is known as the electrical ship. In this type the turbines

Digitized by Google

are connected with generators and have no direct connection with the propeller shafts. Each propeller shaft is connected to driving motors which are run on the electricity generated by the turbo-generators. In these vessels the shafts do not have to run through to the engine room as the motors may be placed as far aft as there is clearance. This type of construction has been developed and adopted by the United States Navy for all its new construction of Capital Ships.

We have given a brief description of the development of marine power units. Before leaving the subject of propulsion it might be well to describe the various contrivances that have been developed to apply the power of these several units. The earliest steam boats were all driven by paddle wheels. Even now boats designed for service in shallow water, such as many rivers, are fitted with paddle wheels. Some of these installations are on the side while others have the paddle wheel on the stern.

We now come to the screw propeller. Many interesting experiments were made by Colonel John Stevens of the U. S. Army on screw propellers but the first commercially successful one was developed by Capt. John Erricson. He took out his patents in 1836. Much improvement has been made since that time on the screw propeller and well designed propellers are now in use in all kinds of service. There is hardly a portion of a modern ship or its equipment that has received more attention along strictly scientific lines than has the screw propeller.

Since a large portion of all ships now built are constructed of steel the remarks that follow are to be considered as relating to vessels constructed of that material especially. Steel ships are now constructed under one of two systems of framing. These are known as the transverse frame and the longitudinal frame or Isherwood systems. In the first the stiffening members or side frames run in the direction of the width while in the other as its name implies they run in the direction of the length of the boat.

By far the greatest number of vessels are still built of the transverse type though most tankers are now built on the Isherwood System. A boat consists first of the outside steel shell or plating, the plates of which are riveted at the ends and sides. The shell in the transverse type is carried or stiffened by channel side frames. In a typical section of the central portion of the ship the side frames extend from the bilge or turn of bottom into the side of the vessel up to the highest deck

Digitized by Google

to which the shell plating is carried. At the bilge the side frame is attached to a piece of plate called the bilge bracket. These bilge brackets carry an angle clip to the shell which has a curved outline and another clip to the tank margin or plating that forms the limit of the double bottom. The double bottom is the space between the outer bottom shell and another set of plating inside the ship which is generally parallel to the bottom shell and about three feet from it. In the cargo vessels of 8,800 DW Ton type this inner bottom or tank top was carried to within about six feet from the sides of the ship and from here was turned down so as to meet the bottom shell just at the turn of the bilge. It is this portion of the inner bottom that turns down which is known as the tank margin and to which the bilge brackets just described are attached. The double bottom is braced first by the centre vertical keel which is a continuous plate girder running full length. At each frame a floor or transverse girder is placed and is firmly connected at bottom with the shell, at the top with the tank top, at the inboard end with the centre vertical keel and at the outboard end with the tank margin. The vertical keel is watertight and floors at stated intervals are also watertight. This construction gives a series of tanks each independent of one another. All floors not specifically watertight have large holes in them which allow the liquid in any tank to maintain a level between all floors. These tanks are used for storage of oil, water, etc., or can be used by filling with salt water as ballast tanks. The ship has usually several decks that run the full length. They are supported on beams that run transversely across the full width of the ship except in way of cargo hatches where they stop at the sides of the hatch.

In all weather decks these are curved up toward the centre providing drainage for water falling on the deck. The decks in the body of the ship are usually flat and do not have camber, as the curvature is called. The deck beams are supported at the end by brackets that rivet to the side frames and in the central portion of the ship by heavy girders running longitudinally. These girders are so placed that they form the sides of the hatches and the short beams have their inboard ends framed into them. In turn the girders are supported at their ends by brackets to bulkheads and at hatch corners by heavy built up columns. Between the tank top or inner bottom and the lower deck and between decks, bulkheads are placed at

Digitized by Google

intervals. These are composed of relatively light steel plates stiffened in the main holds by heavy channels and in the shorter ones by angles. All other details of construction follow similar lines and a further description might prove tedious.

The sizes and weights of the various members of a ship are covered by the rules and are referred to as scantlings. To enable a ready use of tables for these values certain functions of the length, breadth, and height to the lowest deck and to all other decks have been evolved. When once the above dimensions of a ship are known, the numbers are easily computed and following in order the scantlings that correspond to these numbers are found from the tables. In riveting, experience has shown that certain spacing works well, so spacing is specified as a function of the diameter of the rivet as 2½ dia., etc. The thickness of the plate as well as the working conditions require different density of rivets. Oil tight work for instance being the most exacting, as oil will pass a seam that is fully water tight.

The name Lloyds has become identified in the lay mind with ships. Originally the organization that bears that name was simply a gathering of merchants, ship-owners, underwriters, insurance brokers, etc., at a coffee house run by Edward Lloyd. While these meetings were at first very informal the nature of the business that soon began to be transacted gave the name growing significance. As early as 1688 the press took interest in Lloyds, an account of some of their activities being printed in the London Gazette in February of that year. The first printed policy covering marine losses was issued by Lloyds in 1774 and the form then adopted is substantially the same as the one in use today. In 1811 a general reorganization occurred and in 1871 a charter vesting in them all rights as a corporation was obtained through an act of Parliament.

The activities of Lloyds are varied, though they are all the results of systematic studies in an effort to classify shipping with regard to quality of construction and seaworthiness. To obtain insurance a ship must be registered by one of the societies or bureaus, such as Lloyds, The American Bureau of Shipping, etc. The operation of all these is very similar, Lloyds being the oldest and also the best known, having handled the bulk of the world shipping. Recently the American Bureau loomed up as the result of the war activities. If a ship is constructed in accordance with the rules and is inspected (called surveyed) either during

Digitized by Google

construction or subsequent to completion it is given a classification number. These rules also fix the safe carrying capacity of the ship determining the depth to which she is to be submerged when fully loaded. A mark is placed on the sides of a ship at the full load draft line and in the event that the ship owner or captain causes the vessel to be loaded deeper than this mark such action automatically cancels all insurance then in force.

The mark just spoken of is termed Plimsel Mark and is made up of a circle with a vertical and several horizontal lines. Each of these horizontal lines has a special significance though they are all placed in such a position as to give the same displaced tonnage. The upper one defines the submergence in fresh water, the lowest one in salt water of average density, while the intermediate ones apply to varying conditions, such as the one that is marked N A which applies to the North Atlantic regions where the density of the sea water is reduced owing to the presence of large bodies of ice.

Most of the recent shipbuilding activities in this country are being carried out under the rules of the American Bureau which is often called American Lloyds.

The outbreak of the war with Germany created many problems that needed prompt solution. I doubt if there was any one more vital to the winning of the war than that of building ships. All governmental activities were delegated to a group of men who operated as the Emergency Fleet Corporation. The name in itself ought to describe its purpose if that were not otherwise generally known. To obtain greatly increased tonnage this corporation selected certain types of boats as standards and then let numerous contracts for their construction.

The one that has been built in the largest numbers was the 8,800 DW Tons transverse framed freighter. In order to expedite the construction, the simplifying of details was made the preeminent requirement. In the adopted plan, the section was made practically uniform for more than half its length and while the lines so obtained are not matters of beauty, vessels of this type were being produced by many yards in rapidly increasing quantities at the time the Armistice was signed, and are giving excellent service.

To meet the demands for ships many new yards were built and as machinery was hard to obtain many turned out several ships before they were really equipped to handle the work efficiently. At the Southwestern Shipbuilding Company's yard the only

Digitized by Google

machine that was available for shaping shell plates for the early hulls was an old multiple punch gate press. This was modified and fitted up with blocks so as to handle those plates that required the most work but by far the greater number were pulled to place with bolts and jacks. When one realizes that the average thickness of these plates is in the neighborhood of 3/4 of an inch he gets a faint conception of the task involved. Despite all these difficulties by the application of engineering and science along with hard work this yard was able to launch its first boat in 65 working days. This meant that about 3,200 tons of steel were placed, bolted, and a major portion riveted in that length of time. As a matter of comparison if the above steel were loaded on standard flat cars it would take 64 of them to transport the steel for one boat.

A general description has been given of the boat and now we can take up the various steps in its production. The description given is that of the process in a yard that fabricates its own work. By fabricating is meant the punching, shearing, rolling, etc., of the plates or shapes.

The first step in the construction of a ship is the preparation of the drawings. In the hull section the computations and studies made necessary in determining the lines, displacement, etc., call for engineering and applied science of the highest order. The lines of a ship are the lines that delineate the intersections of the molded shape with a set of parallel planes. As is the case with all solids there are three sets possible in a system of rectilinear coordinates, namely length, width, and height. Ships built by either the transverse or the longitudinal system are divided longitudinally in spaces usually equal except at the ends called frame spaces. The transverse lines indicating the intersection of planes through these frame stations, at right angles to the length, with the molded shape and carrying such information as the height to the decks, etc., form what is known as the body plan. The ship being symmetrical with respect to the centre keel, it is customary to give the lines of the fore body on one side of the centre line and the after body on the other. Thus the half body fore and after plans together will give the information necessary as to transverse lines. It is this body plan that is laid down on the mold loft floor. In the drafting room to facilitate the design and computation two other sets of lines are prepared, one showing the resulting line from longitudinal sections cut by vertical planes parallel to and at

Digitized by Google

stated intervals from the centre line of the ship. These are known as shear lines. The last are what are known as the water lines. These are the sections of the ship at the water line for different depths of loading on an even keel. The last two sets are more useful in the design than at any other stage in the construction of a ship. As described before, the scantlings or dimensions of most members of a ship are determined by empirical rules. These rules are those that have been established from experience by Lloyds, American Bureau, etc., and as the stresses existing in a ship are more or less indeterminate and as the rules have been shown to give safe results, few if any computations are made on these details. When we come to the mechanical equipment we find that a similar condition exists, much of this work being based on empirical formulae, though not to the same extent as the hull.

When once the plans are prepared the process in a modern yard moves to the mold loft. The mold loft is a building with a well-matched floor on which a set of lines or body plan is laid down; they are usually drawn full size and the working templates can therefore be picked directly from the floor. Mold loft work is about as good an example as can be obtained of applied descriptive geometry.

For example, in the development of a shell plate template on a curved portion of a ship, the problem becomes one of expanding a warped surface the position and line of its intersection with several parallel planes being known. The template is constructed of light wood strips braced as necessary, only sufficient strips being used to give stock for marking the position of rivet holes. Though this development of the template is a graphical process it does not alter the fact that it is applied science. In the preparation of templates for as large a structure as a ship, engineering principles have many ready applications. Take the matter of clips alone, where two members are connected at an angle approximating 90 degrees, this is usually accomplished by the use of short pieces of angles. These angles are known as clips and by the standardizing of the hole spacing clips were developed that were generally interchangeable. This same principle was applied to the reinforcing angles on the double bottom floors. These floors are the plate girders that separate the inner bottom from the bottom shell. They are designed primarily to give transverse strength and are the continuations of the side frames in the bottom section from the bilge to the keel. Outside of a few

Digitized by Google

of these where special conditions existed they were made interchangeable and were thus designed along true engineering lines.

The finished template has small holes indicating the position of all rivets. To reproduce the template in steel it is firmly clamped down to the steel and the position of each hole is transferred by the use of a centre punch and hammer.

When all the holes have been transferred with a centre punch they are outlined with white paint and any other information necessary in the fabrication of the plates is also painted on. This process is known as laying out and when complete the plate is said to be laid out.

After leaving the layout space the plate goes to the punches, counter-sinking machines, and lastly to the shears. A counter-sunk hole is one that is enlarged with a conical reamer. This is done to allow the forming of a head on the rivets that will be strong, watertight and still not project above the surface of the plate. If full heads were driven on rivets on the outside of the shell, they would produce greatly increased friction. On the decks counter-sunk head rivets are required to produce an even surface and for watertightness.

In some cases planing is necessary, though usually shearing is sufficiently accurate. Those plates that have shape are formed either in a hydraulic press or in bending rolls. Neither of these machines were available when the work described as being done was accomplished on Hull No. 1. The description just given applies with equal force to shapes though in their case they are bent either in a hydraulic ram or by being heated. One of the most interesting sights in a shipyard is the anglesmith's shop where channels used for side frames are heated in a long, tubular furnace and then pulled into shape and held in this shape on a floor made up of large cast-iron blocks.

As far as punching of shapes is concerned it follows the same method as plates though in different types of machines. In cutting shapes that are not too large angle shears are used while the larger ones are cut off with the oxy-acetylene torch commonly spoken of as burned off. Plates with irregular outline are also sometimes burned to shape. The torch is also used for welding operations. Welding is often necessary and where proper ventilation can be secured is accomplished by the use of the oxy-acetylene torch. When work has to be done on enclosed portions of the ship the electric arc is used.

After all the foregoing operations are complete the steel is

Digitized by Google

said to be fabricated and is sent out to the slip. Here it is stored in racks and records kept of its location. In the yard with which I was connected a system was introduced by which it was possible to keep an exact check of the material available and by the use of an order system to have immediate control of the work at all times, even when running 24 hours a day. By the use of these Engineering methods this six slip yard was able to erect over 350 tons per day for some time, and on one day went well over 400. In erecting, the steel is placed in position and enough bolts are placed to keep it in place. After it has been placed men who are known as fitters take care of all the small details and make the whole ready to be bolted up for the riveters. In plating laps there is always a space where one plate is placed on top of another in connecting them, to fill this, steel wedges about 5 inches wide and of varying lengths are used.

They are made as thick as the abutting plate at the thick end and taper to a sharp edge. The fitters get these out by use of a piece of cardboard on which they mark the positions of the holes in the plates. The piece of cardboard acts as a template and the steel wedge is known as the liner. The greatest difficulty in hull construction was incurred in getting the work riveted up. This is extremely hard work and the men who tried to do it did not have the endurance to stay with it long in many instances. After riveting, many seams that have to be watertight are caulked. This consists of upsetting the material of one plate so it crowds in between the two.

When the ship has progressed sufficiently it is ready for launching. The stage at which this occurs in various yards is different, due to their handling equipment. Launching is accomplished in one of two ways, side or end launching. The equipment in either case is similar, consisting of two sets of timbers that are arranged to slide on one another. One set is fast to the slip while the other is built into the timbers that cradle the hull. While under construction the ship is held up by shores and blocks and just previous to launching these are replaced by blocking carried on wedges. As there are released the entire weight of the vessel is transferred to the ways and by simply starting the sliding movement with a jack the ship is launched. To facilitate this sliding the ways are lubricated with tallow or other heavy grease.

After launching the machinery is installed in most yards and the general outfitting takes place. Even in the case of cargo

Digitized by Google

vessels the equipment covers many lines. It includes driving, refrigerating, ventilating, and heating machinery, wireless, electrical, hospital, and cargo handling equipment. The installation as well as its design calls for the application of many scientific principles and the carrying out of the same exemplifies true engineering. When all the above has been placed as well as many things not specifically mentioned the ship is ready to set sail.

If there is any product, the construction of which calls for applied science and engineering it is the steel ship. It is hoped that these few words may have given you an understanding of the history and processes now used in ship construction, particularly the points relating to the practical application of the principles taught by this body of teachers in one of our largest industries.

VALUE OF THE HISTORY OF MATHEMATICAL IGNORANCE.

By G. A. Miller,

University of Illinois.

Suppose that the unreliable portraits of Pythagoras, Euclid, and Archimedes, which appear in some of our textbooks, were replaced by a picture representing a modern high-school pupil in the act of teaching the use of negative numbers to these noted ancient mathematicians. The face of Archimedes might exhibit delight resulting from a clear insight into the importance of these numbers after the matter had received his attention. The face of Euclid might express some doubts as to the desirability of introducing these numbers into the mathematical literature, while that of Pythagoras might express deep meditations on possible and impossible meanings that might be assigned to these new numbers.

Another picture of this textbook might represent a college freshman in the act of teaching Newton some of the uses of determinants, and of telling Euler that it is unwise to regard all negative numbers as greater than infinity notwithstanding the fact that Wallis had drawn such a conclusion from the following infinite series:

$$\ldots\ 1/3<1/2<1/1<1/0<1/-1<1/-2<\ \ldots$$

This freshman might also explain to Descartes the use of the coordinate axes bearing his name and tell Euler that the sum of the series

$$\ldots\ +1/x^2+1/x+1+x+x^2+\ \ldots$$

Digitized by Google

is not identically 0 even if a part of this series can be obtained from $x/x-1$ by division, while the remainder can be obtained from $x/1-x$ in a similar way, and $x/1-x+x/x-1 = 0$ whenever $x \neq 1$.

It is naturally more pleasant to speak of the knowledge of the noted mathematicians of the past than of their ignorance. The great mathematical heritage of our times is due to thousands who worked hard to secure clearer insight and to develop better methods than those which were transmitted to them by their predecessors, and we are justly inclined to think of their contributions rather than of what they failed to see. On the other hand, it is highly desirable to use the best possible methods for acquiring a correct view of the history of our subject. Teachers cannot afford to make it more difficult for their students as a result of an undue reverence for the past.

Such pictures as those suggested above would help the student to see that mathematics is a growing science. They might help the teachers to realize anew the fact that new mathematical ideas are often acquired slowly. As the human race frequently overlooked a fruitful concept which was very closely connected with concepts already in its possession, so the individual frequently fails to grasp what seems to be so easily within his reach. Hence the teacher of mathematics may frequently gain more from a clear exposition of failures than from such an exposition of successes on the part of the eminent mathematicians of the past.

These views may be illustrated by the history of the quadratic equation. One frequently reads that the quadratic equation was solved by Euclid in his *Elements* and in his *Data*. On the other hand it is well known that the Greeks were unfamiliar with the properties of ordinary complex numbers and hence they could not have known the fundamental theorem that the quadratic equation in one unknown has always two and only two roots.

As was implied above, Euclid did not use negative numbers. In fact, he used only one root of the quadratic equation even when both of these roots are positive. With all of these evidences pointing to ignorance as regards certain fundamental facts, on the part of Euclid, one may possibly still be willing to say that he solved the quadratic equation, but it is clear that such a statement will not convey the same meaning as it would likely convey if these evidences were lacking.

A satisfactory solution of the quadratic equation was evi-

Digitized by Google

dently not possible before complex numbers were admitted to full number citizenship. As this citizenship was not granted before the latter part of the eighteenth century it might be said that the solution of the quadratic was not completed before that time, that is, until after the time when the general cubic had been solved algebraically.

Since the ordinary complex numbers are needed for the solution of the general quadratic equation, it might appear natural to assume that the introduction of the complex numbers had been due to a desire to give a satisfactory theory of the quadratic. This assumption is, however, not in accord with the history of our subject. The general solution of the cubic furnished a greater incentive for the study of these numbers than the desire to find solutions of the quadratic in all cases. The fact that when the three roots of the cubic are real, they present themselves in the form of complex numbers seems to have been especially influential in directing attention to the importance of these numbers. A knowledge of the ignorance of the ancient Greeks, the Hindus and the Arabs as regards complex numbers enables one to draw important conclusions with respect to their limitations in the theory of equations. The fact that negative numbers were not fully accepted as numbers until after the days of Descartes (1596-1650) is perhaps still more helpful for the purpose of forming a clear notion as regards certain mathematical attainments of the ancients. Such general negative facts enable the mathematical student to draw important conclusions relating to certain developments made during all the earlier periods just as general theorems enable the mathematician to deduce a large number of special theorems whenever they may be needed.

The discovery of a fundamental mathematical theorem affects mathematical history for all times. The earlier history is affected in view of the fact that the preceding developments relating to this theorem cannot have proceeded as far as the theorem. The later history is affected in view of the fact that the subsequent developments relating to this theorem were probably influenced by it. For instance, the fact that Gauss discovered that a regular polygon of seventeen sides can be inscribed in a circle by means of a ruler and compass implies that for two thousand years after Euclid had published his *Elements* the mathematical world remained ignorant of this fundamental advance in geometry. All later developments relating to this

Digitized by Google

theorem must be considered in the light of the fact that the theorem was known already by Gauss.

The value of the history of mathematical ignorance is mainly due to the fact that a knowledge of the existence of certain ignorance in reference to an important subject enables us to interpret more clearly evidences of partial knowledge relating thereto. For instance, from the fact that the Greeks knew nothing about the theory of permutation and combination, it follows that Euclid could not have made any use of the formulas of these subjects in his *Elements*. Since the Greeks did not assume that there is a (1, 1) correspondence between the points of a line and the real numbers we expect to find in these *Elements* various statements which do not agree with our modern phraseology.

In modern elements of mathematics one would expect something about logarithms and mensuration formulas but we do not expect to find these in Euclid's *Elements* since the former were entirely unknown in his day and practical geometry received little attention on the part of the Greeks until after the time of Euclid. The greatest difference between Euclid's *Elements* and modern elements of our subject relate to the treatment of numbers and elementary algebra for reasons which have already been noted. A study of Euclid's *Elements* in the light of the fact that his treatment was so seriously limited by the lack of knowledge along various lines is evidently more profitable than one based simply on what may be found in this very important work itself.

An emphasis on what was not known at certain periods is more important in the study of mathematical history than in that of the history of other sciences in view of the fact that there is such a close relation between various mathematical developments. In particular, a satisfactory discussion of the solutions of systems of linear equations implies a knowledge of determinants and the Galois theory of equations implies a knowledge of symmetric functions. One might perhaps be inclined to add that a study of spherical trigonometry implies a study of plane trigonometry, notwithstanding the fact that some of the developments in spherical trigonometry preceded corresponding developments in plane trigonometry as a consequence of the recognized usefulness of the former in astronomy.

We have thus far referred only to the mathematical ignorance common to all in the earlier periods of our civilization. The history of mathematical ignorance on the part of a large por-

Digitized by Google

tion of the educated class has not received much attention. In the preface to his book entitled *Easy Mathematics*, 1906, Sir Oliver Lodge said: "The mathematical ignorance of the average educated person has always been complete and shameless, and recently I have become so impressed with the unedifying character of much of the arithmetical teaching to which ordinary children are liable to be exposed that I have ceased to wonder at the widespread ignorance, and have felt impelled to try and take some step towards supplying a remedy."

The mathematical ignorance on the part of the average educated person may perhaps serve to explain the wide-spread erroneous view on the part of many of the ancient people, including the Greeks, that areas of surfaces are proportional to their perimeters. This view was expressed by the noted Greek historian, Thucydides, who lived about the time of Plato and assumed that the area of an island could be determined by measuring its perimeter. The Roman writer, Quintilian, in the first century of our era referred to the fact that it was easy to make people believe that surfaces have the same area whenever their perimeters are equal.

It does not seem likely that even such gross mathematical misconceptions on the part of educated people can ever be entirely eliminated. The efforts of the teachers of mathematics should be directed towards the reduction of the number of those who either hold erroneous views in regard to fundamental mathematical questions or have not acquired sufficient mathematical insight to avoid being misled as regards such questions. The main object of this note is, however, to direct attention to the fact that it is sometimes helpful to emphasize lack of knowledge on the part of the writers of a certain period in order to secure with the least possible effort a correct view of their contributions.

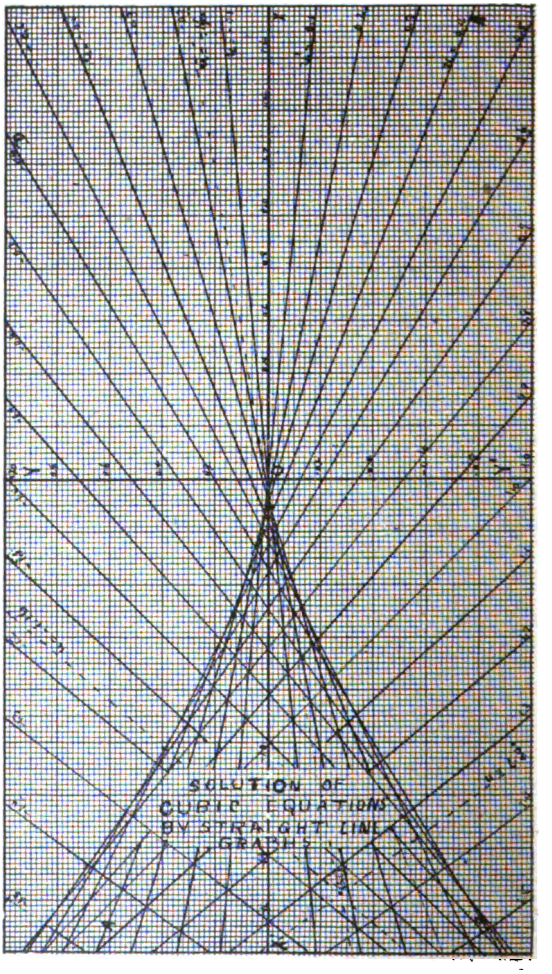
Digitized by Google

SOLUTION OF CUBIC EQUATIONS BY STRAIGHT LINE GRAPHS.

By M. G. Schucker,

Peabody High School, Pittsburgh, Pa.

The complete cubic $z^3+az^2+bz+c = o$ may be transformed into $u^3+su+t = o$. The roots of this equation depend upon the values of the coefficients s and t. If, now, for graphical representation x is taken equal to ks and y equal to kt and substitution is made accordingly in $u^3+su+t = o$, the equation becomes $y+ux+ku^3 = o$. If u be considered a known value, $y+ux+ku^3 = o$ becomes a straight line equation in x and y



Digitized by Google

and may be represented by a series of straight lines by assigning any numerical values to u and k.

The chart represents such a series of lines, when $k = 1$ and u is given the values o, ± 0.1, ± 0.2 . . . That the construction of these lines may become readily evident, the plotting of AB and CD will be given in more or less detail. Let $u = 0.4$, then $y+ux+ku^3 = 0$ becomes $y+.4x+.064 = 0$, whose graph is AB, by using a scale for both abscissas and ordinates such that $5mm$ on the chart shall represent .1 in the values assigned to x and y in plotting. If $u = -0.6$, $y-.6x-.216 = 0$ results, giving the line CD for the graph. Since the substitution of 0.4 and -0.6 for u in the cubic $u^3+su+t = 0$ results in equations $.064+.4s+t = 0$ and $-.216-.6s+t = 0$, it will appear by comparison of these equations with equations $y+.4x+.064 = 0$ and $y-.6x-.216 = 0$ obtained above, that x and y can be interchanged with s and t, respectively.

We are now ready to use the chart for the solution of cubic equations. In the construction of the chart, values assigned to u led to corresponding values of x and y, graphically represented by the straight lines indexed according to the values of u to which they correspond and from which they were derived. Any point (x, y) in the plane may also be designated (s, t). Consequently, it will now be possible, given certain values of s and t, to trace along a straight line through a point (x, y) or (s, t) in a direction and position in accordance with lines already actually drawn and to interpolate an approximate corresponding value of u.

One example will be sufficient to illustrate this. Transform the given cubic $x^3+2x^2-5x-6 = 0$ by substituting $z - 2/3$ for x, obtaining $z^3-6.3z-2.2 = 0$. In this equation $s = -6.3$ and $t = -2.2$. But the point $(-6.3, -2.2)$ is not found on this chart. The chart can be used for values of s and t beyond its range, and the equation chosen illustrates this feature also. To bring the solution within the range of the chart, let $z = 2u$, then $z^3-6.3z-2.2 = 0$ becomes $u^3-1.57u/3-.27 = 0$, an equation corresponding to $u+su+t = 0$. By laying a straightedge along the line through the point $(-1.57, -.27)$, which is the point (s, t) for this equation, in a direction comporting with the lines $u = -1.1$ and $u = -1.2$, the value -1.16 may be approximately interpolated. Likewise, by using the lines $u = -0.1$ and $u = -0.2$, the value $-.16$ may be determined. By using the lines $u = 1.3$ and $u = 1.4$, $u = 1.3$ may be found.

Digitized by Google

Then for $u = -1.16$, $2u = z = -2.33$. $z-2/3 = x = -3$. For the value $u = -.16$, $x = -1$; and for the value $u = 1.3$. $x = 2$. Of course, the values offered here in this sample equation are exact and obtained for the purpose of this paper by accurate and actual calculation, while such exactness is not expected of graphical computation, which is more frequently only approximate.

It will be observed that according as the point (s, t) falls outside of, on the boundary of, or within the triangular shaped region on the left, one, two, or three values of u can be read, and the corresponding cubic equation has one real root only, three real roots two of which are equal, or three distinct real roots.

The chart is merely an illustration of the method. A more elaborate and extensive chart would be accordingly more useful as, by it, it would be possible to solve cubic equations more conveniently and with a higher degree of approximation.

(Note by Math. Ed.—For other examples of the use of graphic charts see, *Graphical and Mechanical Computation*. Lipka, $4.00, 1918, John Wiley and Sons, Inc.; *The Construction of Graphical Charts*, Peddle, 1910, McGraw-Hill Book Co., *How to Make And Use Graphic Charts*, Haskell, $5.00.)

HOW TO TELL GOOD YEAST—IT SHOULD BE FREE FROM DRYNESS, GAS AND OFFENSIVE ODOR.

BY DR. LEONARD K. HIRSHBERG.

It is a simple matter to tell the difference between good fresh yeast cakes and the huge old, dry circular loaf cakes found in a lot of New York East Side shops, and foreign groceries in other cities. Yeast cakes, wrapped in silver foil are almost unknown in these shops, as their patrons, not aware that yeast is a perishable product, do not demand fresh goods. The yeast loaf is sliced down like cheese, and slices are sold until the entire loaf is gone regardless of the length of time it lays on the counter.

Many of the upset stomachs and other digestive disturbances blamed upon one thing or another except the right cause, are really due at times to yeast used in bread, home brew and cakes, which is not the fresh grocery yeast cakes carefully kept in silver foil. The latter are supplied to dealers daily, and are always fresh.

Almost everybody eats yeast these days for beautifying the complexion, warding off sickness, and increasing their powers of endurance, etc.

It is therefore a matter of sensible precaution to follow the advice of the Bureau of Chemistry and the Department of Agriculture and see to it that you obtain the fresh, small individual cakes of yeast at a good grocery store, and thus avoid the fatalities or disturbances which pass under the blame of autointoxication, indigestion, food poisoning and the like.

In all of the experiments conducted by experts, it has been found that the large yeast masses from which foreign stores slice off, and sell dry portions, the stale yeast is not to be trusted, while the small square cakes are always safe.

In this small cake you are sure to obtain the fresh active yeast rich in water soluble vitamines, those essential elements of perfect health and activity.

Digitized by Google

THE PARALLEL DEVELOPMENT OF MATHEMATICAL IDEAS, NUMERICALLY AND GEOMETRICALLY.

By Louis C. Karpinski,
University of Michigan, Ann Arbor, Mich.

The historical development of the fundamental ideas of arithmetic, algebra, and geometry presents a beautiful illustration of the process of evolution in the realm of thought. The continuity of apparently isolated problems and processes reveals the working of law in the unfolding of mathematical ideas. In algebra and in arithmetic, but to a less extent in geometry, the development of fundamental ideas has taken place within fairly modern times, enabling one to trace the gradual unfolding of the scientific ideas involved; in these subjects the present appears as a part of a long past, directly connected with the civilizations of Orient and Occident.

Egypt has often been designated, even by her disciples of modern times, as the exponent of the practical in mathematics. Doubtless the pyramids and obelisks, as monuments to mathematics, have partially determined this view which was first voiced by the "father of history" in discussing the development of geometry as connected with the overflowing Nile. In truth, however, the documentary evidence preserved is eloquent of the purely intellectual interest of the Egyptians in mathematics.

"Find a number which added to $\frac{2}{3}$ of itself leaves, after $\frac{1}{3}$ of the resulting number is subtracted, 10." This problem, truly, and a dozen more like it in the Ahmes papyrus of about 1700 B. C., was occasioned only by intellectual needs. To solve such problems the Egyptian had a fully developed procedure leading certainly to the solution. The formulation of the problem and the conception of the process of solution mark an epoch in the intellectual history of man.

Somewhat similar problems in geometrical terms are found in early Egyptian papyri from Kahun and Illahun. These problems relate to the distribution of a given square area into two squares whose sides have a given ratio to each other. Again the formulation shows that we have here wholly intellectual problems arising from an intellectual interest in the universe of number and form.

The solution of equations appears in Egypt again in a series of problems relating to arithmetical series. Thus in one problem 100 loaves of bread are to be distributed to 5 people according to the terms of an arithmetical series, each one of the group receiving a constant amount of bread more than the preceding

Digitized by Google

one. Here, too, the problem is not a practical problem, concerned with actual affairs; it is a product of thought about numbers.

In ancient Babylon we do not find the equation, the fundamental and basic notion of algebra, playing any rôle. However, other algebraical ideas, such as connected series of numbers and tables, were developed in Babylon. Tables of numerical squares and cubes are found on cuneiform tablets; the particular arithmetical and geometrical series discovered in Babylon are given in connection with a geometrical problem on areas.

The Greek development of mathematics progressed from earliest times along geometrical rather than along numerical lines. The Greek progressed scientifically and logically much further, it must be said, than the Egyptians or Babylonians. Particularly, the Greeks early conceived the notion of a series of logically connected propositions about geometrical figures, which idea culminated in the geometry of Euclid.

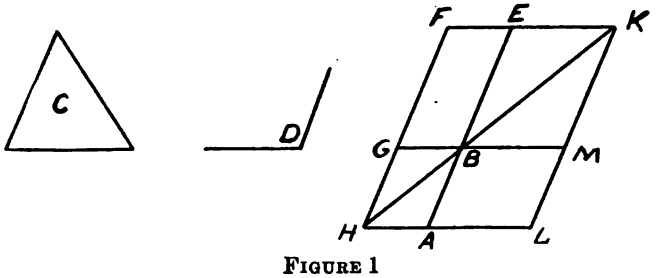


FIGURE 1

The Egyptians thought of an unknown quantity, as we have seen, numerically; the Greek conceived the unknown first as a line. Thus the Greek formulates the first degree equation in geometric language, requiring to determine the unknown side when given the area of a rectangle and one side. The actual formulation in Euclid, I, 44, is: "To a given straight line to apply in a given rectilineal angle, a parallelogram equal to a given triangle," the first of the famous problems on "application of areas." The solution of this problem is remarkable because it involves, in effect, the finding of a fourth proportional without involving the methods of propositions relating to proportion (Euclid, Book V), avoiding thus any discussion of incommensurable magnitudes.

The demonstration as given by Euclid[1] follows:

"Let AB be the given straight line, C the given triangle and D the given rectilineal angle; thus it is required to apply to the

[1]Quotations which follow are from Heath. The Thirteen Books of Euclid's Elements, Vol. I, Cambridge, 1908.

Digitized by Google

given straight line AB, in an angle equal to the angle D, a parallelogram equal to the given triangle C.

"Let the parallelogram BEFG be constructed equal to the triangle C, in the angle EBG, which is equal to D; let it be placed so that BE is in a straight line with AB; let FG be drawn through to H, and let AH be drawn through A parallel to either BG or EF.

"Let HB be joined."

Produce HB and FE to meet at K; through K draw KL parallel to EA and produce HA, GB, to the points L, M.

Then HLKM is a parallelogram.

HFK is equal to HLK, and similarly HGB to HAB and BEK to BMK. By subtraction it follows that the parallelogram ABML is equivalent to the parallelogram GBEF.

"And, since the angle GBE is equal to the angle ABM, while the angle GBE is equal to D, the angle ABM is also equal to the angle D. Therefore, the parallelogram LB equal to the given triangle C has been applied to the given straight line AB, in the angle ABM, which is equal to D."

If b and c represent respectively the sides of the rectangle equivalent to C, within the given angle, and a represents the given line, the theorem presents the solution of the first degree equation,

$$ax = bc;$$

or x is the fourth proportional to a, and b, and c, since

$$\frac{a}{b} = \frac{c}{x}$$

The whole of the second book of Euclid's *Elements* is algebraical, corresponding directly to simple theorems of elementary algebra. With the present algebraical language some of these theorems are, in fact, implicit in the symbolism, hardly capable of proof. As an illustration of the algebraical content of one of these theorems, let us examine Euclid II, 5:

"If a line be cut into equal and unequal segments, the rectangle contained by the unequal segments of the whole, together with the square on the straight line between the points of section, is equal to the square on the half of the line."

Algebraically, this proposition is simply an identity:

$$x(a-x)+(a/2-x)^2 = (a/2)^2,$$

a being any number (or line), x and $a-x$, the two unequal parts of the number (or line), and $a/2$ being half of the number (or line).

Digitized by Google

In the case of external division of the line given in Euclid II, 6, the corresponding algebraical formula is,

$$x(a+x)+(a/2)^2 = (a/2+x)^2$$

which corresponds, of course, to making x negative in the preceding formula.

With the Greek and with the Arab who made the direct algebraical application of Greek geometrical theorems, the negative quantity was not recognized as an independent entity, being always conceived as a positive quantity subtracted from another given positive quantity. The Arab made use of these two theorems, Euclid II, 5 and 6, to solve two types of quadratic equations:

$$x^2+21 = 10x$$
$$3x + 4 = x^2$$

In the first problem the Arab, who starts with the numerical problem, lets a line of unknown length represent x. Then the square upon the line represents x^2. To this a rectangle of area 21 is added, one side of which corresponds to the side of the given square. By the condition of the problem, the square plus the rectangle equals $10x$, whence since one side of the total figure is x, the other side 10. Bisecting the side of length 10, you can apply

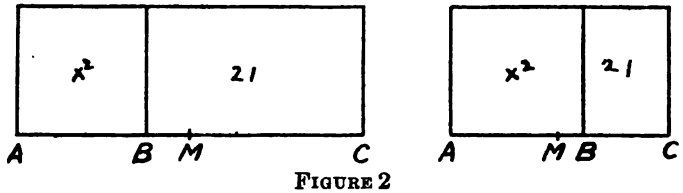


FIGURE 2

$x^2+21=10x$; $x=5+2=7$ $\quad$ $x^2+21=10x$; $x=5-2=3$

$\overline{AM}^2 = AB\cdot BC+\overline{BM}^2$ $\quad$ $\overline{AM}^2 = AB\cdot BC+\overline{MB}^2$

the Theorem of Euclid II, 5, for you have a line divided into two equal and into two unequal segments. Applying the theorem you have that the rectangle upon the two unequal segments, which is 21 by construction, plus the square of the line between the points of section, is equal to 25, the square on half the line. This gives $25-21$ or 4, as the square of that length, 2 as the length between the points of section, and $5-2$, or $5+2$, as the value of the unknown x, according as the rectangle (21) is taken greater or less than the original square.

By these two geometrical theorems Euclid presents the ideas which, expressed in algebraical language, give the solution of two types of quadratic equations. Employing this material of the Greeks, the Arab made real advance by making definite the con-

Digitized by Google

nection between the numerical and the geometrical problems.

Undoubtedly the construction of the pentagon was fundamental in the development before Euclid of Greek logical geometry. The equilateral triangle and the square, the hexagon and the octagon, can be constructed by any school-boy without particular mental effort. But the pentagon requires a different type of mathematical reasoning, including both analysis and synthesis and further a complexity of propositions not found in any other proposition of elementary geometry. With this proposition began almost certainly any wide appreciation of geometry as a logical whole, adapted for instruction.

The pentagon assumed as constructed suggests the five-pointed

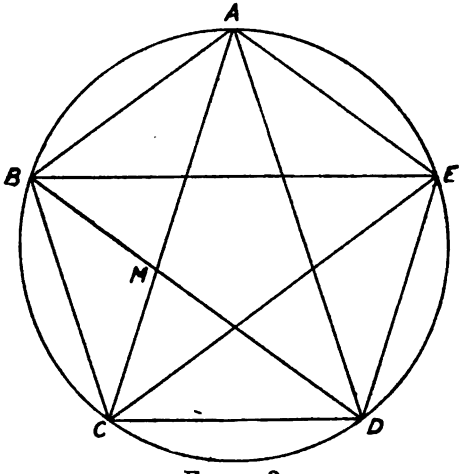


FIGURE 3

star; this being constructed the large isosceles triangle with the base angle double the vertex angle is evident on the figure (ADC); the small triangle (DMC) similar to the large triangle is also apparent in the figure; but this small triangle has as base (MC) the one segment of the side of the large triangle and as a side (MD) a line equal to the other segment (AM) of the side (AC) of the large triangle; by similar triangles,

$$MC : CD = CD : CA,$$

or

$$MC : AM = AM : AC.$$

Thus the problem to construct a pentagon is led by analysis to the problem to divide a line "in extreme and mean ratio," one segment to be to the other as the other is to the whole line. This "golden mean" is then obtained as in Euclid II, 11, by the ordi-

Digitized by Google

nary construction as given in American geometries today, and again in Euclid VI, 30, by "application of areas."

For our purpose the important point is that this fundamental proposition is, in effect, the solution of a quadratic equation,

$$(a-x)/x = x/a$$

or

$$a^2-ax = x^2;$$

the geometrical solution as given by Euclid can easily be shown to follow step by step the ordinary algebraic solution by "completing the square."

Among other primary propositions of Euclid which correspond directly to algebraical problems should be mentioned:

VI, 13, "To two given straight lines to find a mean proportional," which is the solution of the pure quadratic,

$$x^2 = ab;$$

VI, 28 and 29, "application of areas," effecting the geometrical solution of the complete quadratic equations,

$$ax-(b/c)x^2 = k^2,$$

and

$$ax+(b/c)x^2 = k^2.$$

The fact further that the Euclidean discussion of equal ratios (Euclid, Book V) is parallel to the modern algebraic theory of irrationals has already been noted by competent writers.[1]

In recent times it has been shown that only those problems are geometrically capable of solution with ruler and compass, which when expressed in algebraic language lead to problems solvable in terms of quadratic irrationalities, i. e., involving only square roots and not roots of higher order of integral functions of the coefficients. Thus the duplication of the cube algebraically gives the equation,

$$x^3 = 2a^3,$$

whose solution involves a cube root, not reducible. Similarly, the trisection of an angle leads in general to a non-reducible cubic, i. e., a cubic whose solution involves cube roots; the trisection of an angle is not possible with ruler and compass. On the other hand the equation

$$x^{17}-1 = 0,$$

is solvable entirely in quadratic irrationalities, corresponding to the fact that the regular polygon of 17 sides is constructable with ruler and compass; this 17-gon. was the discovery of Gauss while still a youth of 19 years.

[1]Simon, *Euclid und die sechs planimetrischen Bucher*, page 110; Heath's *Euclid*, Volume II, pages 124-126.

Digitized by Google

The analytical geometry and the graphical representation of complex numbers, so-called "imaginaries," are both intimately connected with this geometrical algebra, and those who are familiar with these subjects will appreciate the connection without further explanation. Suffice to say that modern mathematics begins really with Descartes and the complete algebraic treatment of geometrical problems, continued by Newton and Leibniz in the calculus.

The Arabs systematized the algebraic material, adapting it for elementary instruction by writing text-books on the subject. Further than this, the Arabs contributed materially to the fruitful union of algebra and geometry, including the systematic exposition of trigonometry which is also a type of study involving geometrical with arithmetical material.

The first treatise on algebra, *algebr w'almuqabala*, whence the name, was written by Al-Khowarizmi about 825 A. D. Less than a century later one Abu Kamil wrote a much longer treatise in which the important advance was made of the systematic solution of equations in quadratic form ($ax^4+bx^2 = k$, etc.). Al-Khowarizmi had solved quadratic equations geometrically, as indicated above; Abu Kamil solved geometrically not only for x (*shai*) but also geometrically for x^2 (*mal*). With our symbolism the connection between x and x^2 is so patent that this solution both for x and for x^2 is useless; this innovation made by Abu Kamil, adopted a century later by Al-Karkhi, was away from the path of progress, and was not continued by European writers.

About a century after Abu Kamil, the great poet and equally great scientist, Omar Khayyam, began a systematic study of cubic equations. He achieved, apparently independently of Archimedes, a solution by the intersection of conic sections. Certainly his solution has this merit as opposed to that of Archimedes that Omar presented the cubics as a continuation of the quadratic equations. The problem as set by Archimedes was to cut a sphere by a plane into two segments whose volumes should have a given ratio; of this Archimedes gave a solution. Even before Omar's discussion of the problem of the cubics an equally noteworthy step in analysis was made by an Arab in the reduction of the problem of the trisection of an angle to a cubic equation.

Another Arabic work along this line to which I wish briefly to call attention also marks progress in the union of algebra and geometry. The title of this unedited work is "Liber in quo

Digitized by Google

terrarum corporumque continentur mensurationes abhabuchri qui dicebatur heus. Translatus a magistro Girardo Cremonensi in toleto de arabico in latinum abreuiatus." The manuscript which I am using is MS Latin, Paris, 9335, Vol. 116r-126r.

The otherwise unknown author treats a large number of problems on areas and lines, stating "secundum aliabram" or "fac ergo secundum quod processit in questionem aliabre sexta et almuchabala."

Thus the first problem reads to find the side of a square when the area plus the side is given; given the area plus the side equals 110, he obtains the equation "census et res qui equantur centum et decem," i. e., $x^2+x = 110$. The solution is precisely as given by Al-Khowarizmi. The numbering of the types of quadratics also follows Al-Khowarizmi. "Restaura igitur et oppone," is a phrase employed in this work following the terminology of the writer of what may be termed the first text-book on the subject; the words "restore" and "oppose" are translations of Arabic words derived from the same stems as "algebr" and "almuqabala."

The problems which are given by this Abu Bekr are extremely simple. Nevertheless, we have here definite advance in the algebraical treatment of another type of geometrical problems differing from those given by Al-Khowarizmi and Abu Kamil.

In Egypt and in Babylon and in India also we find numerical discussion of several types of algebraical problems, involving in particular cases geometrical areas considered numerically. In Greece similar fundamental ideas were considered primarily from the geometrical standpoint. The contribution of the Arab consisted largely, but by no means wholly, in combining the achievements of the Egyptians and Babylonians and more particularly those of the Hindus and the Greeks. The transmission to Europe of the Arabic mathematical works, in translation, furnished the stimulus for the solution of the cubic and the biquadratic, as well as for the literal algebra of Vieta. Combining this algebraical material anew with the consideration of the geometrical problems on conics furnished by the Greeks, Descartes and Fermat, in the first half of the seventeenth century, discovered independently of each other the analytical geometry. With this union of algebra and geometry modern mathematics had its birth.

Digitized by Google

PROSE PROBLEMS OF ALGEBRA.

By Jos. A. Nyberg,
Hyde Park High School, Chicago.

In two previous papers the writer discussed various problems of algebra whose solutions could be facilitated by using a chart or diagram for the tabulation of the given information. The present paper is hardly more than a collection of miscellaneous remarks and suggestions on problems for which a chart is not essential.

1. Consider first a problem dealing with three or more things, such as:

"The area of Nebraska exceeds the area of Virginia by 34,893 sq. mi.; the area of California exceeds three times the area of Virginia by 30,416 sq. mi., and the area of California twice the area of Nebraska by 3,257 sq. mi. Find the area of each."

The ordinary solution would be:

Let x = area of Virginia.
Then $x+34{,}893$ = area of Nebraska.
and $3x+30{,}416$ = area of California.
$3x+30{,}416-2(x+34{,}893) = 3{,}257.$
. . . . . .
$x = 42{,}627$ = area of Virginia.
$x+34{,}893 = 77{,}520$ = area of Nebraska.
$3x+30{,}416 = 158{,}297$ = area of California.

The precise logic is so evident that it suggests a proof in geometry and one wonders why no one has suggested that the pupil write "quod erat reperiendum" at the end. We know that every geometrical proof involves two steps: The pupil's analysis which he must make for his own benefit to discover the various steps, and the pupil's presentation of the proof which, we might say, is for the benefit of a doubting audience. The solution of the above problem is similarly a presentation. To teach *analysis*, which is necessary before such a presentation can be made, the following method is suggested, the italicized words being the rules which are dictated to the pupil and kept by him for ready reference.

First, *write in a vertical column the various items* (area of Neb., area of Vir., . . .) *which the problem talks about*, writing them in the order in which they are mentioned, and placing after each an equal sign. Placing the equal sign after the item instead of to the left may seem like inconsequential quibbling but it does have some advantages, which will be seen later.

Next, *one of these items we* will *call* x, and *the others will* then

Digitized by Google

be a combination of x and other numbers. If we were clever enough any one of them could be called x; however, *choose the smallest one* if you can decide which is the smallest; if not, *call that one x to which the others are compared.* The pupil has now written what may be called the "preliminary step." The rest of the information in the problem leads to an equation and is a problem of direct translation; *the preliminary steps make the lexicon which tells how to translate into the language of algebra certain English words.* After finding x from the equation, the pupil returns to the preliminary steps to complete the problem which will then appear thus:

$$\begin{aligned}
&\text{Area of Nebraska} = x+34{,}893 = 77{,}520 \text{ sq. mi.}\\
&\text{Area of Virginia} = x = 42{,}627 \text{ sq. mi.}\\
&\text{Area of California} = 3x+30{,}416 = 158{,}297 \text{ sq. mi.}\\
&3x+30{,}416-2(x+34{,}893) = 3{,}257\\
&\qquad\qquad\qquad

James requires only half as much as Elizabeth. What allowance will each child receive?"

The pupil writes in a column: John, Elizabeth, James, with an equal sign after each. Then he writes x in the third line as James receives the least, $2x$ after Elizabeth, and $2x+50$ after John. After the solution has been written on the blackboard, the class is asked how Mr. Brown might solve the problem without any knowledge of algebra. Naturally by trial or guess; and his calculations would appear thus (the teacher writing Mr. Brown's attempts alongside the work already on the board):

John	$= 2x+50$	$=$	90	70	110	80	100	90
Elizabeth	$= 2x$	$=$	40	20	60	30	50	40
James	$= x$	$=$	20	10	30	15	25	20
Total	$= 5x+50$	$=$	150	100	200	125	175	150

The class will then see that among other things, algebra eliminates guess work by its substitution of a letter x for the trial number. Dividing the class into two parts, one half to work by algebra, the other half by arithmetic, let them experiment and see which can determine quickest the various disbursements, if Mr. Brown has 2.95, 3.35, . . to distribute. In attacking any set of new problems where the first ones can be done by arithmetic, it is well to use arithmetic and not discourage its use. Too often in geometry classes a pupil works a problem by algebra when he needs only elementary arithmetic, as for example, when dividing a line 16 inches long into two parts whose ratios shall be 4:3. Of course, the exercises must be so graded that the pupil finally comes to one where he must resort to algebra. Many "time, rate, and distance" and "work" problems can be done by arithmetic, and it is always worth while doing some by that method. The fact that fewer pupils in the class may be able to do the arithmetical reasoning and that the method will be harder for the rest of the class to grasp, will be good arguments for the use of algebra. The class will eventually carry away the notions that algebra eliminates guess work, is a last resort when arithmetic fails, and (regarded as a machine) is easier to understand and manipulate than arithmetic.

But this is not all that can be learned from this problem. Suppose we call the distribution y, so that $y = 5x+5$. The class can see from the figures above that the value of x decides the value of y, and that similarly the value of y (the amount to

Digitized by Google

be distributed) decides the value of x (what James gets). It would be unsound pedagogy to introduce the word *function* but we have here all that the word function implies and we can enlarge on the idea much or little according to the abilities of the class. Certainly it ought not to be passed over without some comment. And if from time to time the pupil's attention is called to such mutual dependences, the explanations which come later will have acquired a meaning, and the teacher will have a foundation on which to build. Even at the risk of interrupting the next day's assignment the class should occasionally be asked to make a more complete table of corresponding values of x and y.

3. In dealing with problems containing a single unknown number we translate the English into the language of algebra. Exercises which reverse this order should also be tried. Thus: The equation $(x-5)\div 6+3 = 2x+7$ was derived in a problem. What was the problem? The pupil answers: If a sixth of a certain number when decreased by 5 is added to 3, the result equals, etc. An occasional five or ten minutes practice on such a translation of a list of exercises, particularly those involving fractions, has its usefulness. For one thing, the pupil will need to watch his English to avoid ambiguity. The above translation, for example is a poor one because it does not state clearly whether the number is divided by 6 before or after the decrease by 5. It is not amiss to assume that this practise will teach him to observe more carefully the wording of the prose problems of the text.

Any equation containing only x may be presented as a conundrum. Thus during the first weeks I say "I am thinking of a number. If I double it, add 10, and divide by 6 I get 5. What number am I thinking of?" In this connection it is also useful to work some of the old parlor games such as: Ask a pupil to think of any number; keeping the number secret, have him multiply it by 5 add 6 divide by 8 and then ask him for the resulting number. The original number can then be determined. The game sounds trivial to an experienced teacher who has forgotten how he himself learned algebra, but to the freshman it is nothing less than wonderful. The process may then be reversed by writing an equation on the board and asking for a statement of the directions to be followed by the computer in determining the original number. This work will involve the substitution of a number for a letter in a polynomial.

Digitized by Google

From this as a basis we can introduce the evaluation of polynomials for a given value of x.

4. Frequently in explaining some problem or method a happy choice of simile or metaphor will not only remove difficulties but make a lingering impression on the pupil. The public orator never hesitates to clinch an argument with a suitable comparison, but our mathematical text books contain very few. It would seem as if the writers feared losing their dignity. Hence, fully realizing any such possible loss, I add the following illustration. To solve the equation

$$6(3x-2)-5(2x+1) = -4(5x-3)+83$$

we imagine ourselves in the place of a grocery clerk in the shipping department, say, who receives from the wholesaler three kinds of packages. He gets 6 of one variety labeled as containing* $3x$ and -2; he gets -5 of another variety containing $2x$ and $+1$, and -4 packages of another variety; also, a $+83$ unwrapped. To examine the goods he must *unwrap the packages, having then*

$$18x-12-10x-5 = -20x+12+83.$$

His next work would be to *sort the various goods* putting the x in one pile, the constants in another just as if sorting apples in one bin and potatoes in another. Hence the pupil writes:

$$18x-10x+20x = 12+5+12+83.$$

In the transposition, certain signs are changed, of course—which is one way in which algebraic quantities differ from apples. *After sorting, the clerk counts how many* apples *he has*, how many potatoes, etc.; and so the pupil's next duty is to count how many x's he has, how many constants. Hence $28x = 112$. We see that the illustration can not be carried too far, but the pupil will see that he (1) removes parentheses by multiplication, (2) rearranges by transposing, (3) simplifies by addition, and (4) finds x by division.

Another illustration occurs in handling radicals. When it becomes necessary to simplify radicals I personify the radical sign comparing it to a very fastidious landlord who will not shelter a tenant who is a fraction or is divisible by a perfect square. If a pupil forgets to simplify such a quantity I have merely to say "Consider your fastidious landlord." I have heard of a teacher who compares the perfect square factor of the radicand to a beautiful princess imprisoned in a tower from

*The writer does not regard $3x-4$ as the subtraction of a 4 from a $3x$ but as the addition of a $3x$ and a -4. See the paper "Plus and Minus Signs in Algebra" in the May issue.

Digitized by Google

which she is to be brought outside by a knight, the pupil. And the linear relation which can sometimes be derived from a set of simultaneous quadratics is a "Wandering Willy" lost and concealed in a forest of x's and y's. Undoubtedly many teachers use such comparisons. It is unfortunate that the textbooks on pedagogy do not contain a collection of these useful comparisons.

5. Every text when considering equations divides the work into two parts, the exercises and the problems. The exercises are the equations for whose solution certain directions are given. Then as an application these exercises are followed by problems (variously called "prose" problems or "word" problems) leading to equations of the type which the exercises have illustrated. This is the usual order in the chapter introducing parentheses, or when fractions are first used, or in the chapter involving quadratics, etc. This order is regarded as necessary for unless the pupil knows how to solve a certain type of equation, he can not complete the problem. To consider the problem first would also have its advantages because it is concrete whereas the exercise involves an abstract x, and because it would justify the study of the new equation by showing how it arises. Hence I have tried the following combination of the two methods. I consider the problem first, discuss the unknown element, the given information, and derive the equation. I treat in this way all the problems that I intend to assign and set each equation aside (writing them in one corner of the blackboard) for future reference, pleading inability to solve it because of insufficient knowledge of algebra. Then, after making a list of the equations, I ask in what way these equations differ from previous ones. After fixing the attention on the parenthesis, or the denominator, or the quadratic term we begin the study of the equation and work the exercises, returning last of all to the problems again. At times several days or a week may intervene between the first time the problem is studied and the final solution of it. But this plan keeps a single definite object before the pupil at all times, concentrates the attention on the new element as it arises, and emphasizes the idea that the solution of the problem is the important end, that the equation is a means or tool for that end, and that all the rest of the work is intended to develop proficiency in handling the equation.

6. The first months of algebra contain many problems involving two unknowns wherein the sum of the two is given;

Digitized by Google

and one of the most difficult ideas for the pupil to grasp and use is that if the sum is 60, for example, and one unknown is called x, then the other must be $60-x$. Usually a text leads up to this quantity $60-x$ by various questions (all of which the pupil may answer correctly, and still the next day use $x-60$ instead of $60-x$) or else impresses it by writing

$$\begin{aligned} \text{smaller number} + \text{larger number} &= 60 \\ x \qquad\quad + \text{larger number} &= 60 \\ \text{larger number} &= 60 - x \end{aligned}$$

which is a good method if transposition has already been considered (as the writer believes it should be). But after many attempts the writer has found that the easiest method is to use two letters x and y, and let the pupil write $x+y = 60$. This involves an early use and solution of linear simultaneous equations. Why not adopt the principle that no method should be taught which will subsequently be replaced by an easier one unless the first method teaches something which the pupil can not learn from the second. In other words, no method is to be studied and used for itself alone, but only for what it can contribute toward a solution of a problem. It would seem then that the prose problems of the first months of algebra which require a good bit of explaining and which can be solved more easily by simultaneous equations either ought to be omitted entirely or else solved by simultaneous equations. It is possible to organize the first year of algebra in such a way that almost all of the first semester's work will be devoted to the study of equations and problems leading to equations. To the second semester we could postpone all multiplication of binomials, division of polynomials by binomials, and all the work on factoring. In their place we would then have equations involving fractions with numerical or monomial denominators, their numerators being binomials. And such an arrangement would give ample time for simultaneous equations earlier in the year.

A STUDY IN DETERMINANTS.

By C. M. Himel and C. A. Stone,

Maine Township High School, Des Plaines, Ill.

In solving by determinants the following rule is given: "Any unknown is equal to a fraction whose denominator is the determinant of the system and whose numerator is the determinant formed from the determinant of the system by substituting for the coefficients of the unknown sought the corresponding known

Digitized by Google

terms with that sign attached to each known term which it has when on the side of the equation opposite the unknowns."

In the above rule let x be the unknown, N the numerator of the fraction, and D its denominator.

Evidently we have the following:

$$x = \frac{\begin{vmatrix} k_1 & b_1 & c_1 & \cdot & \cdot & \cdot & l_1 \\ k_2 & b_2 & c_2 & \cdot & \cdot & \cdot & l_2 \\ k_3 & b_3 & c_3 & \cdot & \cdot & \cdot & l_3 \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ k_n & b_n & c_n & \cdot & \cdot & \cdot & l_n \end{vmatrix}}{\begin{vmatrix} a_1 & b_1 & c_1 & \cdot & \cdot & \cdot & l_1 \\ a_2 & b_2 & c_1 & \cdot & \cdot & \cdot & l_2 \\ a_3 & b_3 & c_2 & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ a_n & b_n & c_n & \cdot & \cdot & \cdot & l_n \end{vmatrix}}, \text{ or } x = \frac{N}{D}.$$

Obviously N and D differ only in the first columns.

From $x = \frac{N}{D}$ we get $xD = N$ and subsequently $xD - N = 0$, where D is not 0. xD may be expressed as a determinant by multiplying each element of column one in D by x, for, if all the elements of a row (or column) of a determinant are multiplied by the number x the determinant is multiplied by x.

$$\therefore xD = \begin{vmatrix} a_1x & b_1 & c_1 & \cdot & \cdot & \cdot & l_1 \\ a_2x & b_2 & c_2 & \cdot & \cdot & \cdot & l_2 \\ a_3x & b_3 & c_3 & \cdot & \cdot & \cdot & l_3 \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ a_nx & b_n & c_n & \cdot & \cdot & \cdot & l_n \end{vmatrix}$$

Likewise $-N$ may be expressed as a determinant by multiplying all the elements of column one of N by -1. Thus:

$$-N = \begin{vmatrix} -k_1 & b_1 & c_1 & \cdot & \cdot & \cdot & l_1 \\ -k_2 & b_2 & c_2 & \cdot & \cdot & \cdot & l_2 \\ -k_3 & b_3 & c_3 & \cdot & \cdot & \cdot & l_3 \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ -k_n & b_n & c_n & \cdot & \cdot & \cdot & l_n \end{vmatrix}$$

Substituting in the equation $xD - N = 0$ we get,

$$\begin{vmatrix} a_1x & b_1 & c_1 & \cdot & \cdot & \cdot & l_1 \\ a_2x & b_2 & c_2 & \cdot & \cdot & \cdot & l_2 \\ a_3x & b_3 & c_3 & \cdot & \cdot & \cdot & l_3 \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ a_nx & b_n & c_n & \cdot & \cdot & \cdot & l_n \end{vmatrix} + \begin{vmatrix} -k_1 & b_1 & c_1 & \cdot & \cdot & \cdot & l_1 \\ -k_2 & b_2 & c_2 & \cdot & \cdot & \cdot & l_2 \\ -k_3 & b_3 & c_3 & \cdot & \cdot & \cdot & l_3 \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ -k_n & b_n & c_n & \cdot & \cdot & \cdot & l_n \end{vmatrix} = 0.$$

Digitized by Google

The above is the sum of two determinants which differ in one column only, and can be expressed as one determinant by changing a_1x, a_2x, a_3x, etc., to a_1x-k_1, a_2x-k_2, a_3x-k_3, etc. This is in conformity with the rule which states that if one row (or column) of a determinant has as elements the sum of two or more numbers, the determinant can be written as the sum of two or more determinants.

Call the new determinant E.

$$E = xD - N = 0, \text{ or}$$

$$E = \begin{vmatrix} a_1x-k_1 & b_1 & \cdot & \cdot & \cdot & l_1 \\ a_2x-k_2 & b_2 & \cdot & \cdot & \cdot & l_2 \\ a_3x-k_3 & b_3 & \cdot & \cdot & \cdot & l_3 \\ \cdot & & \cdot & \cdot & \cdot & \cdot \\ \cdot & & \cdot & \cdot & \cdot & \cdot \\ a_nx_n-k_n & b_n & \cdot & \cdot & \cdot & l_n \end{vmatrix} = 0.$$

Thus $E = 0$ gives a simple equation in x from which x can be found by one determinant instead of two, as in $x = \frac{N}{D}$.

Another advantage is that E being zero, m times any column (of row) may be added to n times any other column (or row), also any column (or row) may be multiplied by m; m and n being two real numbers not zero.

After x has been found from $E = 0$, then y, z, w, etc., are found by the same method, using one column and one row less each time.

Let us solve by the above theorem the following:

$$\begin{aligned} 4x-3y &= 5. \\ 8x+y &= 17. \end{aligned}$$

Solving for x:

$$E = \begin{vmatrix} 4x-5 & -3 \\ 8x-17 & 1 \end{vmatrix} = 0.$$

$$\therefore \quad 4x-5+24x-51 = 0.$$

$$28x = 56.$$

$$x = 2.$$

Solving for y:

$$E = \begin{vmatrix} 4 & -3y-5 \\ 8 & y-17 \end{vmatrix} = 0.$$

$$\therefore \quad 4y-68+24y+40 = 0.$$

$$28y = 28.$$

$$y = 1.$$

Digitized by Google

THE PLACE OF NATURE STUDY IN THE ELEMENTARY SCHOOL CURRICULUM.

By S. H. Williams,

State Normal School, Slippery Rock, Pa.

The development of esthetic appreciation in any individual is closely associated with the elevation of mind to a higher plane of moral ethics.

In no other way can this appreciation be greater imbued than by introducing to the individual the wonders of the natural world. This introduction should be made early in his life, just as is the training in morality, ethics, and social responsibilities, and proceed through successive stages of intensive observation to and through adolescence when, by virtue of previous training, he will continue his observations and investigations with a manifest interest which will lead him into realms of Nature's glory and closely associate him with that divine power which has made all things possible.

We have made one advance in this direction by shifting the study of natural science from the college to the secondary schools where Chemistry, Physics, and Biology are taught sometimes in, I am afraid, a rather indifferent way. We have further broadened our vision and established a course in General Science in the first year of the secondary schools. Of course the Science has not yet reached its plane of perfection or greatest usefulness but its progress indicates that it will shortly attain an effectiveness that will emphasize its importance.

It is true that the place Natural Science now holds in the curriculum of the various grades of schools, has been made possible after a long and bitter struggle against the inertia of prejudice and routine but the victory has been a glorious one.

But why stop here? To postpone the revelations of Science until the adolescent period is analogous to beginning the study of the history of civilization at the sixteenth century without reference to the preceding ages through which it has evolved and from which the greater part is inherited. Or like beginning Algebra at Quadratics. Furthermore when a child reaches the age of puberty he has passed the age of "inquisitiveness," during which he has made our lives miserable with his incessant propounding of questions relative to the moon, stars, the rainbow, clouds, colors and odors of flowers, the birds, and a multitude of other things which only the imaginative, wondering, unconcentrated mind of a child could think of—oft times to our shame

Digitized by Google

and embarrassment at being unable to explain them. As a consequence, we ourselves can remember how our desires to know these things were suppressed by a "run along and play I'm busy and don't (emphasis on the don't) ask so many questions." This remark was often accompanied by the quotation of the old saying, "A fool can ask more questions than a dozen wise men can answer." But these questions are not foolish and we should see to it that the parents and teachers of the future will be able to answer them and enlighten the questioner as well as to encourage him in his desire to know.

Isn't it logical that this period is the time of times to make the introduction of the charms and wiles of Mother Nature to the youth?

Then why wait until the boy and girl have reached the High School, where they are confronted with the cold indifferent facts of Chemistry and Physics, before making their debut in the field of Science? Why waste the golden opportunities in child life when their very souls are burning to know—to learn—to love?

There is a saying that "It is hard to teach an old dog new tricks," and as certain as are the immortal truths of Geometry is it that after the child has reached adolescence it is harder to interest him in a new field. This is partly because he has become indifferent to the things which have been a part of his environment all his life and he has learned to take them as a matter of course. This would be a sad and sorrowful world if the training in morals and religion were postponed until this time. But if the secrets are revealed during his early life—how they grow, how the desire to know and learn more will manifest itself in productive effort.

Therefore it is advisable that a course in nature study be incorporated in the elementary school curriculum. Connect the collegiate and secondary courses with a primary foundation and they will be productive of more good.

The traditional method of introducing the Sciences into the schools first from the university to the college and from the college to the secondary schools has been like starting to build a chimney from the top downward and unlike any other subject that has ever received a place in the course of study. We do not begin mathematics at Calculus but proceed from the most elementary foundation. Neither do we begin Latin by reading Horace. So we must have a gradation of subjects in Science.

Digitized by Google

We must lay a foundation on which to build and proceed carefully to construct a stable, thorough knowledge which will precede a higher step on the ladder of learning.

It is easy to assert that the course should be given but when the matter of what it should contain is considered it causes no little concern for each teacher of Science has a different idea of the content. There are so many wonderful things in nature that it is difficult to choose those things which are of most worth. But one thing at least will be agreed upon; the course should contain elementary explanations of things which are constantly before the student, the common things, if you please, the knowledge of which will aid him in his struggle for existence and develop in him that esthetic appreciation, which is so valuable an asset to any individual and to the group.

In the elementary grades stories of animals, plants, and natural phenomena, told in the same way and in the same language as the "Uncle Remus" tales, or in the form of the beautiful story of the "Two Rain Drops" which was written by Doctor F. B. Pearson, former Superintendent of Public Instruction, in Ohio, could be used to advantage. These stories could replace, to a certain extent, the mythical tales about Santa Claus, etc., which lead the child to believe in something with so strong a conviction that when he learns that his idol is imaginary and false it causes utmost grief. I know of many a child who has cried as though his little heart would break when informed that there was no such a being as Santa Claus.

There may be some who will ask how much of this will be remembered by the child after years have gone by when he will be called upon to utilize this knowledge. I would answer such a person in a truly American fashion of answering a question by asking one. How much does he remember of anything he has studied? Furthermore how many of us have studied Mother Goose since the days of our childhood yet in the entertainment of our children we can sing and recite those little songs and stories by the hour. There will be some who can and will make rhymes of some of this information, although that would not be my idea for I believe we agree with Oppenheim that rhymes are the hardest things for a child to learn and understand. We do not want the facts to be learned in a sing-song manner but rather told and learned in a way which the word learn implies. Nor do I wish to eliminate the little fairy tales which mean so much to the child in the period of "make believe," for I love

Digitized by Google

children too much to rob them of any of their joys. But the truth, if properly told, is more fascinating than fiction and will do infinitely more good.

In the intermediate grades school gardens, home experiments, and school projects may be utilized. In the Grammar Grades laboratory and field work may be ably done and insect collections made. That this motivates the work in the whole school is subscribed to by many schools in the United States where this is in part carried out.

I shall not present here my outline of the course for the various grades, as it is not my intention to thrust upon others my ideas as to content but rather to present an argument for the course which should be standardized by the blending of ideas of a large number of capable teachers and students. There will be a tendency, no doubt, as was the case in General Science, to emphasize the divisions of Science in which the writer of text books is especially versed or interested. But no course of study has ever stood the test of time but has been subjected to the tests of usefulness and efficiency. So, too, the work in Nature study will be tested and varied until its plane of greatest good has been determined. It will be the object of criticism and ridicule, but like the others it will soon, perhaps sooner than we think, find its channel and when this has been accomplished; when it begins to function properly, this old world of ours will be a better place in which to live.

THE OUTLINE OF A COURSE IN PRACTICAL CHEMISTRY FOR GIRLS.

By Charles E. Dull,

South Side High School, Newark, N. J.

Feeling that the college preparatory course in chemistry does not meet the needs of students who enter business directly from high school and that it is not well suited to girls who enter normal school, we are giving courses in chemistry which we believe such students will find of more value to them than the regular preparatory work.

In the chemistry for girls, the nature of chemical action, how chemical changes are brought about, and the demonstration of the various classes of chemical change are taught in practically the same manner as in the regular preparatory chemistry.

In the study of oxygen and hydrogen, their preparation is left entirely to the laboratory. In discussing their properties,

Digitized by Google

emphasis is placed upon the special properties which make them fitted for certain uses.

After the general properties of an acid have been discussed and demonstrated, several samples are shown, including not only the strong mineral acids, but such acids as boric, acetic, citric, tartaric, tannic and oxalic. Since practically all of these are found in every household, their occurrence and uses are studied briefly at this time.

In a similar manner the general characteristics of bases are taken up. The vigorous action of soluble bases on fats and oils is briefly considered. With these bases aqua ammonia as a weaker base is contrasted. Demonstrations are used to show that washing soda, borax and soap have an alkaline reaction in solution, thus explaining their action as solvents of grease.

Eight or ten salts are used to show the variation in color, solubility, crystalline structure and chemical behavior which leads to so many different uses.

The question of theory is rather a difficult one in such a course. It seems to me that each pupil should have a clear conception of atomic weight, the atomic theory and the law of definite proportions. Each one should know the significance of symbols, and formulas, and be able to interpret equations. I expect the pupils to know how to find the molecular weight of a compound from the tables of atomic weights, to figure its percentage composition and to solve simple problems involving chemical equations.

I treat nomenclature quite as fully as in the regular course and valence a little more briefly. The treatment of solutions does not vary from that of the regular course.

The subject of fuels and illuminants is considered with combustion and oxidation. Wood, the various kinds of coal, oil and gas are compared with respect to cost, fuel value and waste products. If the class has not studied physics, we include diagrams showing the proper regulation of drafts, check-drafts and dampers. Diagrams of smoke consumers are used to show the effect of more efficient oxidation. These topics include the principles of extinguishing fire; applications of the three methods; and references to fireproof materials and the fire-proofing of cloth.

The operation of the bunsen burner is compared with the ordinary gas burner to show how to secure the highest efficiency. Coal-gas, water-gas and acetylene are studied as fuels and il-

Digitized by Google

luminants. Comparison is made between the fish-tail burner and the gas mantle as to efficiency.

In the lesson on the composition of the air, no difference is made except the greater emphasis upon methods of ventilation, the use of ozonized air and the effect of relative humidity.

In the chapter on water, the color, odor, and turbidity are first studied. The distinction between pure and wholesome water is emphasized as well as the effect of organic matter in drinking water. Natural soil filtration, mechanical filtration, boiling, aeration, coagulum precipitation and distillation are studied in their relation to water purification. The use of ozone, chlorine, and copper sulphate as methods of chemical purification are discussed. This chapter also includes such topics as the value of hard water for drinking purposes, its disadvantages for use in laundries, dye-works, paper-mills and steam boilers, and the methods used for softening hard waters.

Considerable attention is given to the study of foods, including the following topics: Starch, its occurrence and conversion into glucose and dextrine; the occurrence of several sugars and their importance as food; proteins as found in meat, eggs, flour, milk and legumes; the occurrence and extraction of fats and oils; and emulsions and saponification.

Following a comparison of the values of the various methods of cooking, the need for preserving foods that are not to be used for immediate consumption is shown by a brief discussion of molds, yeasts and bacteria. Especial emphasis is placed on the study of conditions favorable to their growth; this is followed by a discussion of the various methods of preservation: Canning, the use of sugar, pickling, smoking, drying, refrigeration, sterilization and pasteurization of milk, and the use of chemicals.

Some of the important foods are studied in greater detail. In bread-making the study of the action of yeast is followed by a discussion of the action of such leavening agents as baking powder, soda and sour milk, molasses, or simple aeration. The use of shortening is briefly discussed.

The value of milk as a food includes a study of its source, how easily it may be contaminated, souring due to lactic acid bacteria, and certified and condensed milk. Such foods as cream, ice-cream, butter and oleomargarine are studied in class. A brief study of such beverages as tea, coffee, and cocoa is included at this time. In the study of foods the most common adulterants are discussed, the nature of adulterants, and the objections to their use; whether injurious or a cheaper substitute.

Digitized by Google

Since several organic substances find extensive use in the home or the arts, the properties and use of the following are taken up: Grain, wood and denatured alcohol, carbolic acid, glycerine, formaldehyde, chloroform, iodoform, carbon tetrachlorid, and a few esters and organic acids.

Under textiles we study the source of the various fibers and the action of chemicals on these fibers. This furnishes us a basis for the laboratory tests for these fibers and also makes the chemistry of bleaching and stain removal more intelligible.

In the study of laundering the methods of making soap are considered, the quality of soap, the action of free alkali, adulterants and fillers, the use of special soaps and cleansing agents and the need for the use of bluing, and the action of the various kinds.

The study of paints, oils and varnishes includes a comparison of zinc and lead as paint bases, the action of linseed oil, the use of pigments, stains and driers, and a discussion of the various kinds of varnishes.

Comparatively little time is given to the study of the metals. The physical and chemical properties that make such metals as tin, lead, iron, zinc, silver and aluminum useful in the household are studied. Such topics as the action of alkalies on aluminum cooking utensils, the solvent action of some drinking waters on lead pipe, the tarnishing of silver in the presence of sulfids and the use of such action in making oxidized silver, the rusting of iron and the use of tin or zinc as a protective coating, the use of alloys and plated ware, and the methods of cleaning and polishing metals form the bulk of the work on metals.

The manufacture of the various kinds of glass and the discussion of the different kinds of pottery are topics which are given a very brief consideration.

The majority of the students find time to perform nearly all the experiments in the following list:

1. Preparation and properties of oxygen.
2. Preparation and properties of hydrogen.
3. Preparation and properties of hydrochloric acid (typical).
4. Preparation and properties of sodium and calcium hydroxides.
5. Preparation of salts. (Illustrating three methods.)
6. Presence of water in salts and its effects.
7. Quantitative determination of water in cryst, barium chloride.
8. Preparation of solutions; saturation; effect of temperature.
9. Destructive distillation of wood and coal. (Fuels and illuminants).
10. Properties of carbon; use as deodorizer and decolorizer.
11. Preparation and properties of carbon dioxid.
12. Distillation; coagulum purification of water.
13. Preparation and study of hard waters. Softening of hard waters.

Digitized by Google

14. Tests for simple impurities in drinking water.
15. Test for starch in several foods.
16. Test for glucose in several foods.
17. Test for proteins in several foods.
18. Test for fats and oils in several foods.
19. Milk; Babcock test; lactometer test; preparation of pasteurized milk; effect of rennin (junket tablets).
20. Preparation of baking powder. Tests of commercial powders.
21. Tests for preservatives: (a) formaldehyde in milk; (b) boric acid in wafers, ice-cream cones and milk; (c) salicylic acid or benzoic acid in catsup, jams, etc.; (d) sulfites in sausage and hamburg steak; (e) saccharin in canned corn.
22. Tests for adulterants. Selections are made from the following: (a) Starch and gelatine in ice-cream; (b) turmeric in mustard; (c) coal-tar colors in candy, jellies or butter; (d) chicory or cereals in coffee; (e) cottonseed oil in olive oil; (f) oleomargarine or process butter for butter; (g) copper salts in canned vegetables; (h) adulterants in vanilla or lemon extract; (i) adulterants in maple syrup; (j) glucose in candy; (k) manufactured vinegar for cider vinegar.
23. Test rancidity of butter or olive oil.
24. Test for alcohol in drugs; per cent of alcohol in drugs.
25. Tests for wood alcohol as a substitute for alcohol.
26. Extract caffein from coffee; thein from tea; test "Kaffee Hag."
27. Test headache powders for acetanilid.
28. Determine acidity of vinegar.
29. Determine purity of baking soda and cream of tartar.
30. Determine amount of soluble matter in tea.
31. Determine the amount of water oysters lose by drainage.
32. Examination of fibers; action of chemicals on linen, wool, silk and cotton.
33. Analysis of mixed fabrics.
34. Soap making. Free alkali in soap. Insoluble matter in soap.
35. Removal of stains: ink, grease, grass, coffee, tea, fruit, vaseline, mildew, iodin.
36. Preparation of aluminum hydroxid and its use with logwood and alizarin as a mordant.
37. Dyeing; direct dyes; basic dyes.
38. Study of solutions of resins in sodium hydroxid, linseed oil, alcohol and turpentine as varnishes.
39. Photography; blue prints.
40. Test paper, cloth, etc., for arsenic. (Gutzeit test.).

COLLEGE ENTRANCE EXAMINATION BOARD QUESTIONS IN CHEMISTRY.

By Henry Lester Gerry,

Worcester Academy, Worcester, Mass.

Recently the writer has taken occasion to examine rather carefully the questions in chemistry set by the College Entrance Examination Board during the past ten years. This was done with the view of determining, if possible, the portions of elementary chemistry which the examiners seem to have considered most important or, at least, have asked most frequently. Such an analysis as this has been does not lend itself easily to verbal description; nevertheless, it is the purpose of this paper to try to point out some of the conclusions that may be drawn

Digitized by Google

with comparative surety relative to the general nature of the chemistry examinations of the period from 1911 to 1920.

This investigation used the "Definition of the Requirements in Chemistry" (College Entrance Examination Board Document, No. 93), and the examination questions of the past ten years as a basis for work. At the time the material was gathered, the fall Comprehensive Examination for 1920 had not been given, so those questions are not considered in this paper. In all, then, eighteen sets of examination question papers were scrutinized; ten of the Old Plan, the June Comprehensive Examinations for 1916 and 1920 and the June and September Comprehensive Examinations for 1917, 1918 and 1919. For each topic set down by the Board in its list of requirements the corresponding questions or parts of questions were noted in "A Collection of Representative Questions." Thus one question in an examination paper may appear as several items in the just mentioned collection. For example: In 1918 the following question was asked: "How would you prove, by chemical means, the presence (a) of carbon monoxide if mixed with sulphur dioxide? (b) of hydrogen if mixed with dry air (if the amount of hydrogen is too small to make the mixture explosive)? (c) of gold in copper? (d) of sulphuric acid in a solution of hydrochloric acid?" In the "Collection of Representative Questions" parts of this question appeared as four separate and distinct items under properties or recognition of carbon monoxide of hydrogen, of gold and of sulphuric acid; and perhaps might well have been placed in several other categories. Again, one part ("The water solution of a certain substance gives the following tests: The solution gives a deep-red color with ammonium or potassium thiocyanate [NH_4CNS or KCNS], and with barium chloride solution a white precipitate insoluble in hydrochloric acid. What may the dissolved substance be?") of a question asked in 1919 was twice entered, first under "recognition of ferric chloride" and again under "experiments." This method of analysis gave nearly 900 items from the eighteen examinations. Since not all questions on College Board Examinations have the same grading value, since the questions were dissected and part-questions entered in the material from which generalizations have been drawn, and since these part-questions often were entered more than once, the number of items under any one topic does not give the relative value in the minds of the examiners of that phase of the subject, but rather furnishes a

Digitized by Google

rough measure of the frequency of recurrence of that topic.

Anyone who has just thumbed over the pages of the question papers doubtless has been impressed with the almost certain annual recurrence of a series of partial equations. It is doubtful, however, if the casual observer has noticed the frequent recurrence of the equations representing a reaction in which barium sulphate is formed, copper reacts with nitric acid, hot concentrated sulphuric acid and copper interact and in which the products of heating concentrated nitric acid are indicated. In some form or other the barium sulphate reaction occurs no less than five times; the copper-nitric acid, three; the copper-sulphuric, twice; and the nitric acid, twice.

Every question paper within the period under examination, whether in Old Plan Examinations or in the Comprehensive Examinations in Chemistry, has had at least one problem in simple chemical arithmetic, with predominance held by problems concerning the volume of a gas derived from a known weight of one of the reacting substances. In each Old Plan Examinations since 1910 there has been an average of nearly five questions, or parts of questions, which required an arithmetical solution. In eight Comprehensive Examinations since 1915, about four stoichiometrical problems have averaged to appear in each paper. The relative frequency of the most common of these problems may be seen in Table I.

Table I.
Frequency of Most Common Numerical Problems in College Board Examinations, 1911-1920.

Type of Problem	Per cent of Frequency		
	Old Plan	Comprehensive	All
Law of Boyle	9.1	6.3	7.9
Law of Charles	9.1	12.5	10.5
Definite proportions	2.3	0.0	1.3
Multiple proportions	4.5	3.1	3.9
Percentage composition	18.2	25.0	21.2
Weights of substances concerned	20.4	18.7	19.7
Volume of a gas resulting from a reaction	36.4	34.4	35.5
Total	100.0	100.0	100.0

Almost every, if not every, examination question paper has dealt in some manner with the Electrolytic Dissociation Theory. It may have contained a question for the explanation of a simple case of electrolysis, of neutralization, of the reaction to litmus

Digitized by Google

of a dilute solution of copper sulphate or sodium carbonate, or a question regarding the use of electricity in electroplating, or any two or more of these divisions of the topic. Some one of the other theories or some common law of Chemistry is scarcely ever omitted from a question paper. Knowledge of the Laws of Boyle and Charles until recently have been tested by numerical problems. However, the June, 1920, Comprehensive Examination had a question designed to determine the understanding of the relationships between volume, temperature and pressure of a gas without asking for a statement of the laws or for a solution of a problem. The Law of Definite Proportions and the Theory of Valency have recurred intermittently. Of course, knowledge of the one is taken for granted when problems in percentage composition are solved; and familiarity with the other, in the writing of equations. Table II attempts to show the relative frequency of questions on some of the theoretic phases of the requirements.

TABLE II.

Frequency of Most Commonly Occurring Questions on Chemical Theory in College Board Examinations, 1911-1920.

Subject	Percent of Frequency		
	Old Plan	Comprehensive	All
Law of Boyle	6.2	6.5	6.3
Law of Charles	6.2	10.9	8.1
Law of Conservation of Mass	4.6	0.0	2.7
Law of Conservation of Energy	3.1	0.0	1.8
Law of Definite Proportions	9.2	0.0	5.4
Law of Multiple Proportions	4.6	4.4	4.5
Law of Gay-Lussac	3.1	4.4	3.6
Atomic Theory	7.7	8.7	8.2
Avagadro's Hypothesis	0.0	4.4	1.8
Electrolytic Dissociation Theory	26.2	41.2	32.4
Valence (aside from equations)	6.1	0.0	3.6
Energy Changes	4.6	6.5	5.4
Oxidation and Reduction	13.8	10.9	12.6
Catalysis	4.6	2.1	3.6
Total	100.0	100.0	100.0

It is unusual to find a question paper that does not in some way draw upon the laboratory experience of the student for the material of the answer. Questions of this nature have been those asking for the description of a piece of laboratory procedure, for the identification of specified substances, for the separation of two somewhat similar materials, or for means of distinguishing pairs of elements or compounds. This type of

Digitized by Google

question has made up 11.6% of the items of the Ordinary Examinations and 7.6% of the Comprehensive.

In the Old Plan Examination papers, questions requiring information about the common non-metallic elements have occurred nearly twice as frequently as those on the common

TABLE III.

Relative Frequency of Some of the More Common Topics Found in College Board Examinations, 1911-1920.

Topic	Percent of Frequency		
	Old Plan	Comprehensive	All
Common non-metals	17.7	25.4	20.3
Common metals	9.2	7.4	8.6
Common acids	17.2	28.6	21.1
Salts, oxides and hydroxides	39.5	21.3	33.3
Gases, not elements	16.4	17.3	16.7
Total	100.0	100.0	100.0

metallic elements and less than half as many times as those on metallic salts, oxides and hydroxides. Questions on non-elementary gases and on common acids each have occurred in the

TABLE IV.

Frequency of All Topics in College Board Examinations, 1911-1920.

Topic	Percent of Frequency		
	Old Plan	Comprehensive	All
Common non-metalic elements	8.0	9.0	8.4
Common metallic elements	4.2	2.6	3.6
Common acids	7.8	10.2	8.7
Salts, oxides and hydroxides	17.9	7.6	13.8
Gases (not elements)	7.5	6.1	6.9
Organic substances	2.5	2.6	2.5
Identification (laboratory)	11.6	7.6	10.0
Quantitative experiments	0.55	0.6	0.6
Equations	12.4	17.8	14.5
Reversible reactions	1.0	2.2	1.4
Laws and Theories	6.3	5.2	5.9
Electrolytic Dissociation Theory	3.1	5.2	3.9
Chemical arithmetic:			
Percentage composition	1.5	2.3	1.8
Weights of substances concerned	1.7	1.7	1.7
Volumes of gas from a reaction	3.0	3.2	3.1
Energy changes	0.55	0.9	0.7
Oxidation and reduction	1.7	1.5	1.7
Solutions	1.5	2.9	2.1
Others	7.2	10.8	8.7
Total	100.0	100.0	100.0

same series of papers nearly as frequently as those on the non-metallic elements. These five groups of questions have comprised quite 45% of the items in the ten Old Plan Examinations

Digitized by Google

since 1910. In the Comprehensive Examinations the relative proportions among these five items are somewhat different. Here, as in the other set of papers, questions on the common metals are least frequently asked, questions on non-elementary gases occur more than twice as frequently and from three to four times as frequently are found questions on common non-metallic elements, on common acids and on salts, oxides and hyrdoxides. This relationship is shown in Table III.

Table IV is a summary of the relative frequency of items found in both kinds of examination question papers from 1911 to 1920.

CHEMICAL NOMENCLATURE AND PRONUNCIATION.

By J. Norman Taylor,

Washington Preparatory School, Y. M. C. A., Washington, D. C.

The attention of educators is frequently called to the responsibility of secondary schools in the matter of preparing students for institutions of higher learning. Slow progress in college is attributed to lack of proper training in the student's preparatory life and not infrequently, failure in later life is ascribed to faults of secondary schools. A well-known research director, in writing of the lack of observation among chemists, states that "until a conscious effort is made in our primary education to meet this requirement, our advance in science will not be as speedy as it should."[1] A prominent educator implies this same lack of adequate preparation when he says, "And even if a freshman is somewhat dulled by his previous training, that seems scarcely a good reason for going on with the dulling process."[2] Not only as regards preparation in science is deficiency laid at the door of the secondary school, but the poor English employed by so many college graduates is likewise charged to the same source. "A university graduate's inaptitude in the art of writing may be due, however, not to faults in his university course; more likely it is due in part to inefficient methods employed in the schools in which he obtained his earlier training in English."[3]

Granting the fact that the lower schools are responsible for deficiencies which handicap the individual later on, it will be agreed that in secondary schools, method is of great importance. If we are to utilize the scientific method in teaching science, then it

[1]Rose, Robert E., "The Education of the Research Chemist": Jour. Ind. and Eng. Chem., vol. 12, p. 948, 1920.
[2]MacArthur, C. G., "The Scientific Teaching of Science": Science, new ser., vol. LII, p. 350, 1920.
[3]Wood, George McLane, "Suggestions to Authors": U. S. Geological Survey, p. 52, 1916.

Digitized by Google

follows that in English-speaking countries good English, both with regard to spelling and pronunciation, should be used to convey our thoughts regarding science.

Although perhaps not a vital matter, it nevertheless appears to the writer that in teaching chemistry, the nomenclature used in secondary schools, so far as chemical words and terms are concerned, should agree with that employed in the higher institutions of learning. Dean Wilbur in speaking of good use in language, with particular reference to national use, says, "There is a law of national use that restricts us to those words that are in good use throughout the land. . . . A word that is not in good current use throughout the land is inefficient. Misunderstanding and perplexity and vagueness follow in the track of such a word."[4] In instances where chemical facts have been conveyed to the preparatory school student through the medium of corrupt English, confusion is bound to follow when his teacher in college uses pure English. And a change from pure English to corrupt forms is equally confusing. Certainly, there should not be any confusion in this regard and greater uniformity should obtain both as to terminology and pronunciation.

If it is correct to spell the word phosphorous with "ph," why should not the same principle in orthography be followed when writing the word sulphur? Good English would require that the names of the members of the halogen group be spelled with the final "e," as "fluorine," "chlorine," "bromine," and "iodine," and that they be pronounced as they are spelled and not as though the termination were "in." Likewise good English demands that the names of the chemical compounds known as the halides be spelled with the final "e"[5] and that they be pronounced as they are spelled. The names of analogous compounds should terminate in "ide," as for example: carbide, oxide, sulphide, phosphide, nitride, selenide. The names of these compounds should not be pronounced as though they terminated in "id." Acids, bases, and salts should be written and pronounced with a proper regard for good English.[6] In naming salts, the negative terminations should be "ate" and "ite" and the names should be

[4]Wilbur, William Allen, "English Rhetoric": Judd and Detweiler, Inc., Washington, 1917, p. 260.

[5]Consult "Inorganic Nomenclature" in the introduction to a "German-English Dictionary for Chemists," by Austin M. Patterson, published by John Wiley and Sons, Inc., New York, 1917.

[6]Examples of good chemical nomenclature are to be found in "A Dictionary of Chemical Terms" by James F. Couch, published by D. VanNostrand Co., New York, 1920.

[7]Crane, E. J., "Chemical Nomenclature": Jour. Ind. and Eng. Chem., Vol. 11, p. 72, 1919.

Digitized by Google

pronounced as they are spelled and not as though they terminated in "at" and "it."

We must conclude with Dr. Crane that "good English in chemical literature, particularly in naming compounds, needs cultivation."[7] Its choice is based on a proper regard for derivation and good usage, and this latter desideratum requires the use of pure English by English speaking people, both in writing and pronunciation. Elimination of un-English terminology in chemical literature may be brought about by following Dean Wilbur's injunction: "Cultivate your own heritage. Cast away your mannerisms and discard your provincialisms, but cherish as a trust your own style and express it in our common language for the common good." Let those who teach chemistry in our schools and colleges observe good usage and adhere strictly to real English rather than to individual preferences.

FORD EDUCATIONAL LIBRARY.

Ford Motion Picture Laboratory is engaged in the production of an educational film library, to be known as the "Ford Educational Library," that will provide for the public and private schools and colleges of every nation in the civilized world films distinctly for class-room use in the way that will make them of greatest value and easiest to obtain. By placing at the service of every educational institution a product based on the principles of sound pedagogics and edited by leading professors of the universities of the United States and competent authorities in screen instruction in the schools Henry Ford not only will supply school needs but will fulfill the ambitions of the pioneer professors and instructors, until now seriously handicapped in their efforts to secure films designed by teachers for teachers' use in class-room work. On September 1, the first issue of this library will be available to every school in the United States. The subjects will be specially prepared for use in any class-room by members of the scholastic profession who are experts in their particular line and the units as arranged will be distributed under a plan that will fully meet all conditions in each school, whether the schools be large or small. The library will further offer to every university and college in the United States facilities for the production by their own professors of films for world-wide school use in any quantities that may be necessary to meet the constantly increasing demand.

Doctor S. S. Marquis, former dean of St. Paul's Cathedral, Detroit, Michigan, who has represented Henry Ford for a number of years, will have general charge of the Ford Educational Library. Dr. W. H. Dudley, Chief of the Bureau of Visual Instruction, University of Wisconsin; Professors Charles Roach, Visual Instruction Service, Iowa State College of Agriculture and Mechanical Arts; J. V. Ankeney, Visual Presentation Department, University of Minnesota; and W. M. Gregory, Director of Visual Instruction, Cleveland, Ohio, Normal Training School, are associated and actively engaged in the editing and final review and approval of the films. Distribution and general subscription arrangements will be supervised by Messrs. Fitzpatrick & McElroy, 202 So. State Street, Chicago. Mr. John P. Brand, former manager and editor of "Moving

Digitized by Google

A New Book with a Big Record

Published a little over a year ago, GRUENBERG'S ELEMENTARY BIOLOGY already has an enviable record of classroom adoptions. It is widely recognized as the leading textbook in its field.

It is a book with a different viewpoint, in that it emphasizes the relation of biology to the problems of everyday living. It deals with the world of life as a whole rather than with the arbitrary divisions of the specialist. It stresses the economic importance of plant and animal products.

Here is a book that will arouse a new interest in your biology classes.

GINN AND COMPANY

2301-2311 Prairie Avenue Chicago, Illinois

Picture Age," one of the foremost motion picture magazines devoted to visual education, will assume the duties of general manager of distribution and subscription.

The making of this film library will in no way conflict with the entirely separate production and distribution of the "Ford Educational Weekly" which, as a popular means of general entertainment and instruction, has proved itself of lasting value. Special buildings containing all necessary and up-to-date laboratory and photographic equipment have been prepared for the new Ford Laboratory because of the enlargement of its activities and it is now in full operation. Every mechanical device that can be used to promote the production of the Library and "Ford Educational Weekly" has been installed and the laboratory itself stands as a finished example of scientific and economical motion picture production on a large scale.

The first issues of the Ford Educational Library are but a part of the output that will follow, covering the entire field of visual education. Plans for production and distribution are such that a maximum supply of the best films that can be made by the most prominent educators will be finished and supplied to the world. The founding of the library marks another forward step in the motion picture industry and the realization of the desire of the prominent teachers and students of the world.

Digitized by Google

PROBLEM DEPARTMENT.

Conducted by J. A. Nyberg,
Hyde Park High School, Chicago

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. If you have any suggestion to make, mail it to him. Address all communications to J. A. Nyberg, 1044 E. Marquette Road, Chicago.

SOLUTION OF PROBLEMS.

661. *Proposed by Jas. H. Packham, Collegiate Institute, Owen Sound.*

Given an $\angle ABC$, a point Q on BC, and a point P between the sides of the angle. Construct an isosceles triangle, having its vertex on AB, its base on BC, one extremity of the base at Q, and the side opposite Q passing through P.

I. *Solution by Norman Anning, Ann Arbor, Mich.*

Let BA have the equation: $y = kx$;
BC the equation: $y = o$;
Q the coordinates: (a, o); and
P the coordinates: (b, c). Let S be the other extremity of the base of the isosceles triangle, and let it have the coordinates: (s, o) where s remains to be determined.

The vertex, R, of the isosceles triangle lies upon the lines $2x = a+s$, $y = kx$, and, consequently, has the coordinates

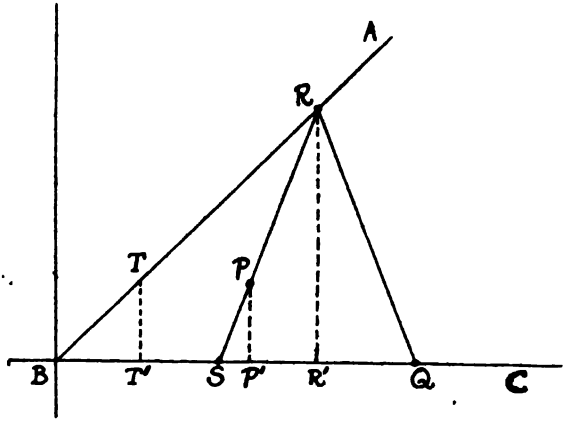
$$[(a+s)/2,\ k(a+s)/2].$$

Now P lies upon the line RS, hence

$$\begin{vmatrix} s, & o, & 1 \\ b, & c, & 1 \\ a+s, & k(a+s), & 2 \end{vmatrix} = 0.$$

or

$$s^2(k)+s(ak-bk-c)-abk+ac = 0.$$



Since s is a root of a quadratic equation whose coefficients are functions of the known quantities, a, b, c, k, its value can be constructed, step by step, with straight-edge and compasses.

Similarly solved by A. Pelletier, Montreal, Can.

II. *Comment by the Editor.*

After discovering the solution by analytic geometry as above, it is

Digitized by Google

RESISTANCE SPOOLS

1236S. Resistance Spools. Set of eight for use with Wheatstone Bridge. Nicely finished wood base with pegs for holding the spools when not in use. Set consists of the following spools wound with No. 30 D. C. C. German Silver Wire: 1 with 40 cm, 1 with 80 cm, 1 with 120 cm, 1 with 160 cm, 2 with 200 cm, 1 with 200 cm, No. 28 D. C. C. German Silver wire, and 1 with 2,000 cm No. 30 D. C. C. Copper wire. Per set.....$6.50

1240S. Resistance Spools. For use with Wheatstone Bridge. Accurate to 1-2 of 1 per cent.

Ohms	1	2	5	10	100	200	1000
Each	$ .80	$ .80	$ .95	$1.25	$2.25	$2.75	$4.00

1244S Resistance Coil. 1 ohm, on wood spool, each.....$ .45

1248S Resistance Coil. 1,000 ohms, on wood spool, each.....$ .60

No. 1240S

Catalog S-20 lists a complete line of Scientific Apparatus and Supplies. Send for your copy NOW

E.W.A. ROWLES CO.

·MANUFACTURERS·

SCHOOL FURNITURE AND SUPPLIES

2345-51 SO. LA SALLE ST.

CHICAGO, ILL.

possible to translate the analysis into the language of elementary geometry because the problem involves only lines. Thus:

Instead of saying the equation of BA is $y = kx$, we will select an arbitrary length BT′ for unity. Draw T′T, PP′, RR′ ⊥ BC. Measured with BT′ as a unit, let the lengths of the various lines be: T′T = k, P′P = c, BP′ = b, BS = s, BQ = a. We calculate BR′ = $(a+s)/2$ since R′ is the midpoint of segment SQ. From the similar triangles BT′T and BR′R, we calculate R′R = $k(a+s)/2$. Then from the similar triangles SP′P and SR′R we derive the proportion SP′/P′P = SR′/R′R, which reduces to

$(b-s)/c = (a-s)/k(a+s)$ or $s^2k+s(ak-bk-c)-abk+ac = 0$.

Here s is the unknown which is to be determined.

The reader who is unfamiliar with such a method of analysis may wonder why we are permitted to choose *any* length BT′ for unity. This question would be answered if we try to carry out the construction. For example, we must find the products ak, bk, etc. The fourth proportion to BT′, a, k, would be ak; the fourth proportion to BT′, b, k, would be bk. And changing the length BT′, would also change k, but leave ak or bk unchanged. As a matter of fact bk is merely the length of the perpendicular to BC from P′ to its intersection with BA, and ak is the length of the perpendicular to BC from Q to its intersection with BA. These lengths are independent of any choice of BT′.

662. *Proposed by J. L. Riley, Stephenville, Texas.*

If a, b, c, d are the sides, and $\triangle$ the area, of a quadrilateral inscribed in a circle of radius R, prove that

$$16R^2\triangle^2 = (ab+cd)(bc+da)(ca+db).$$

Solution by J. H. Packham, Owen Sound, Can.

Let A, B, C, D be the vertices of the quadrilateral, AB = a, BC = b, CD = c, DA = d, AC = e, BD = f. Then

$2\triangle = ab\sin B + cd\sin D = (ab+cd)\sin B$

since B and D are supplementary angles. Similarly,

$2\triangle = (ad+bc)\sin A$.

Drawing a diameter from D, we see that $\sin A = BD/2R$; and similarly, drawing a diameter from C, $\sin B = AC/2R$. But since the quadrilateral is inscribed in a circle, $ef = ac+bd$ (Ptolemy's Theorem). By substitution and multiplication we derive the desired equation.

Digitized by Google

Also solved by N. Anning, A. Pelletier, W. R. Warne.

663. *Proposed by A. Pelletier, Montreal, Canada.*

Prove that the product of four consecutive numbers can not be a perfect square.

Solution by L. E. Mensenkamp, Freeport, Illinois.

If we denote the four consecutive numbers by n, $n+1$, $n+2$, and $n+3$, we have the identity

$$n(n+1)(n+2)(n+3) = (n^2+3n)(n^2+3n+2) \qquad (1)$$

where the first member of the right hand side is obtained by multiplying the first and last factors of the left hand side, and the second factor on the right side is the product of the two intermediate factors of the left side.

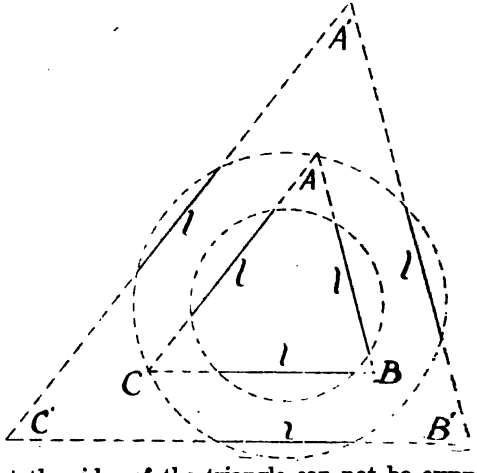
If we set $k = n^2+3n+1$, we see from the right side of (1) that our given product becomes $(k-1)(k+1) = k^2-1$. Hence the product of our four consecutive numbers is always equal to the square of an integer diminished by one, and therefore can not itself be the square of an integer.

Also solved by N. Anning, J. H. Packham, W. R. Warne, and the Proposer.

664. *Proposed by N. P. Pandya, Amreli, Kathiawad, India.*

Three equal chords (length l) of a circle form, when produced both ways, a triangle ABC. Express the sides of the triangle in terms of its angles and l. Hence find under what circumstances the sides would be in geometrical progression.

Remark by A Pelletier, Montreal, Can.



It seems that the sides of the triangle can not be expressed in terms of its angles and l. The figure shows that two triangles may have the same angles and l, and still have their corresponding sides unequal.

665. *Proposed by W. R. Warne, State College, Pa.*

Solve $\cos(ax) \cdot \cos(bx) = \cos(a+c)x \cdot \cos(b+c)x$.

Solution by J. F. Stecker, Pennsylvania State College, Pa.

Since $2\cos(ax)\cos(bx) = 2\cos[(a+c)x]\cos[(b+c)x]$,

$\cos(a+b)x+\cos(a-b)x = \cos(a+b+2c)x+\cos(a-b)x$,

or, $\cos(a+b)x = \cos(a+b+2c)x$,

$(a+b)x = 2k\pi \pm (a+b+2c)x$

where k is any integer, positive, negative or zero.

Solving for x, $x = k\pi/c$, $k\pi/(a+b+c)$.

Also solved by N. Anning, J. H. Packham, A. Pelletier, and the Proposer.

PROBLEMS FOR SOLUTION.

676. *Proposed by W. R. Warne, Pennsylvania State College, Pa.*

A quadrilateral ABCD is such a one that a circle can be inscribed in it and another circle circumscribed about it. Prove that

$$\tan^2 A/2 = bc/ad.$$

Digitized by Google

Announcement

to

Educators, Boards of Education and Commercial and Industrial Laboratories Interested in Laboratory Furniture

The Chicago Office

The Kewaunee Mfg. Co.

Laboratory Furniture Experts

is now located at 308 South Wabash Ave., 8th Floor, Kimball Bldg., Telephone, Wabash 6157. You are cordially invited to inspect our sample display.

Mr. A. E. Kaltenbrun has been selected as Manager of the Central West Sales Division, covering Iowa, Illinois, Indiana, Michigan and Wisconsin. Mr. Kaltenbrun will be glad to talk over with you your requirements. Our Engineering Service is free.

Our many years of successful experience in manufacturing Laboratory Furniture for Educational and Industrial purposes has equipped us to serve you intelligently and promptly.

Address all correspondence to

Kewaunee Mfg. Co.

LABORATORY FURNITURE EXPERTS

114 Lincoln Street

Kewaunee, Wis.

New York Office, 70 Fifth Avenue

BRANCH OFFICES:

Chicago	Atlanta	Dallas	Kansas City	Spokane
Columbus	Alexandria, La.	El Paso	Minneapolis	San Francisco
	Little Rock		Denver	

Digitized by Google

677. *Selected.*

Prove the following theorem due to Ceva (Milan, 1678):

Lines drawn through the vertices of a triangle, and passing through a common point, determine upon the sides six segments, such that the product of three non-consecutive segments is equal to the product of the three other segments.

678. *Proposed by A. Pelletier, Ecole Polytechnique, Montreal, Can.*

Prove that the square of an integer is never of the form $12n+5$.

679. *Proposed by several contributors during the past year.*

At what time past h o'clock is the minute hand m minutes ahead of the hour hand, assuming naturally that both hands move at a uniform rate and not by jerks?

680. *For undergraduates. See announcement in October issue. Proposed by Norman Anning, Ann Arbor, Mich.*

If it requires 11 "rounds" of the binder to cut one-half of a rectangular wheat field and 14 more to cut the remainder, find the ratio of the length of the field to its width. All swaths are full width.

The department frequently receives problems concerning the value of which it is undecided, either because of the difficulties involved or because the interest may be limited. Three are presented below. The editor invites an expression of opinion. Solutions if received will be presented.

A. *Proposed by R. T. McGregor, Elk Grove, Cal.*

If on an average of one vessel in every ten is wrecked, find the chance that out of five vessels expected at least four will arrive safely.

B. *Proposed by J. H. Packham, Owen Sound, Can.*

The arc of a circle is one mile long and the chord of the arc is six inches less. Find the radius of the circle.

C. *Proposed by Burrell Morgan, Panther, W. Va.*

By arithmetic solve: Over what area can an aviator gaze when up 2,000 feet above the open ocean?

SCIENCE QUESTIONS.

Conducted by Franklin T. Jones,

The Warner & Swasey Company, Cleveland, Ohio.

Readers are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves Kindly address all communications to Franklin T Jones, 10109 Wilbur Ave., S E., Cleveland, Ohio

Please send examination papers on any subject or from any source to the Editor of this department. *He will reciprocate by sending you such collections of questions as may interest you and be at his disposal.* **Ask for the examinations you would especially like to get.**

FOREIGN EXAMINATIONS.

The editor of this department desires to obtain examinations in NATURAL SCIENCE (as well as other subjects) from schools in France, Belgium, Italy, Spain, Denmark, Sweden, Norway and Finland Any reader of SCHOOL SCIENCE AND MATHEMATICS in these countries will confer a great favor upon the editor by writing to him upon this subject.

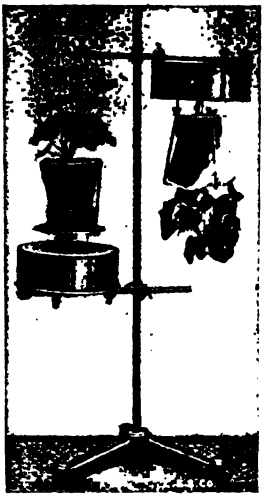
QUESTIONS AND PROBLEMS FOR SOLUTION.

In the June, 1920, number of SCHOOL SCIENCE AND MATHEMATICS, page 556, there was published an examination in *Dynamics* from the Scottish Universities Entrance Board. You are requested to give these problems to your classes in physics, or to individuals, and send in their solutions, right or wrong.

There follows below two examination papers, one given in March, 1919, by the Scottish Universities Entrance Examination Board and one given in June, 1920, by the College Entrance Examination Board. Obtain solutions of the problems numbered:

349, 350, 351, 352, 353, and *354.*

Digitized by Google



About Clinostats

"The Clinostat is an indispensable instrument for any thorough work not only upon geotropism, but also upon other phases of the irritability of plants."—Prof. W. F. Ganong.

The Cambridge Clinostat illustrated here is now used in Botanical Laboratories throughout the United States because:

1. Its specially adapted, eight-day, Seth Thomas movement is reliable;
2. Its universal adjustment carries the plant horizontally, vertically, or at any intermediate angle; (Note the two positions shown above).
3. Its substantial construction assures years of satisfactory service.

32-37 **Cambridge Clinostat,** with lacquered brass dial, oxidized case, and universal stand.....**$30.00**

Note: Write now for Bulletin 221 on Agricultural Equipment

Cambridge Botanical Supply Company
LABORATORY EQUIPMENT FOR ALL SCIENCES
Waverley, Mass.

Neufeld's Elementary Algebra With Table of Logarithms

The practical value of algebra is always in evidence in Professor Neufeld's textbook. It is a real teacher's helper. The pupil's excuse, "I couldn't understand the explanation in the book" disappears with its use.

With 34 Illustrations. Cloth **$1.45** Postpaid. By J. L. Neufeld, Central High School, Philadelphia.

Tower, Smith, Turton and Cope's "Physics"

"It is a stimulus, a challenge and a guide to thinking about familiar physical phenomena out of which must grow a knowledge of physics. It impresses the pupil with the fact that physics is an inseparable part of the life of every one able to see, hear, feel, taste or smell."

With 455 Illustrations, including 7 plates. Cloth **$1.35** Postpaid. By Willis E. Tower; Charles H. Smith; Charles M. Turton; Thomas D. Cope.

P. Blakiston's Son & Co. Publishers PHILADELPHIA

Digitized by Google

SCOTTISH UNIVERSITIES ENTRANCE EXAMINATIONS.

DYNAMICS.

Wednesday, 19th March, 1919, 3 to 6 p. m.

A Candidate may obtain FULL *marks by doing about two-thirds of this Paper.*

Marks will not be awarded to answers where the work is not shown.

N. B.—*Candidates must write on their books the number of the table at which they sit.*

1. Define Uniform Velocity, and explain what is meant by Relative Velocity.

One ship sails west at the rate of 20 miles per hour from a point 10 miles due south of another ship which is sailing due south at the rate of 15 miles per hour: find the relative velocity of the first ship with respect to the second.

349. The measure of an acceleration when the units of space and time are a foot and a second is 3. What would be the measure of the same acceleration when the units are a yard and a minute?

A body starting from rest, and moving with uniform acceleration, describes 16 1/4 ft. in the seventh second of its motion: find the acceleration.

3. Show how a force may be completely specified by means of a finite straight line.

Two forces whose magnitudes are 30 and 40 respectively act at right angles. Find their resultant force. Resolve this resultant force into two components, one of which is a force of magnitude 60 at right angles to it.

4. Find the resultant of two unequal parallel forces acting on a body in opposite directions.

350. The arms of a balance are unequal in length. If a mass appears to weigh 25 grammes when placed in one scale pan, and 24 grammes when placed in the other pan, find its real weight, if the weights of the arms and the scale pans may be neglected.

If the arms are equal but the scale pans are of different weights, and the mass seems to weigh 25 grammes and 24 grammes, in the respective pans, find its real weight.

5. Find the Centre of Gravity of a triangular lamina.

From a corner of a triangular plate is cut off a fourth part of its area by a straight line parallel to its base. Find the position of the Centre of Gravity of the remainder.

351. Three weights of 1, 2, and 3 lbs. respectively are placed at the angular points A, B, C of an equilateral triangle. Find the perpendicular distance of their common Centre of Gravity from the side BC when the side of the triangle is 2 ft.

6. Define Work; and Kinetic and Potential Energy.

When a body moves in a straight line under the action of a uniform force, show that the change of kinetic energy per unit of space is equal to the acting force.

Find the work done in dragging a weight of 100 lbs. through 100 ft. up a rough inclined plane inclined at 30° to the horizon, assuming the coefficient of friction to be $1/\sqrt{3}$.

7. Prove that the algebraic sum of the moments of two parallel forces about any point in their plane is equal to the moment of their resultant about the same point.

352. A uniform bar, 3 ft. long and weighing 5 lbs., can turn freely about a point 11 inches from one end, and from that end a weight of 15 lbs. is suspended. From what point of the bar must a weight of 30 lbs. be suspended so as to preserve equilibrium?

8. (*a*) Make a drawing of a system of three pulleys in which the strings are attached to the weight; and find the relation between the power and the weight.

353. (*b*) If each of the three pulleys weighs 2 pounds, find the weight raised if the power applied be 16 pounds weight.

9. Explain the meaning of the term *Density* of a substance.

(*a*) Explain how you would find the Sp. Gravity of lead.

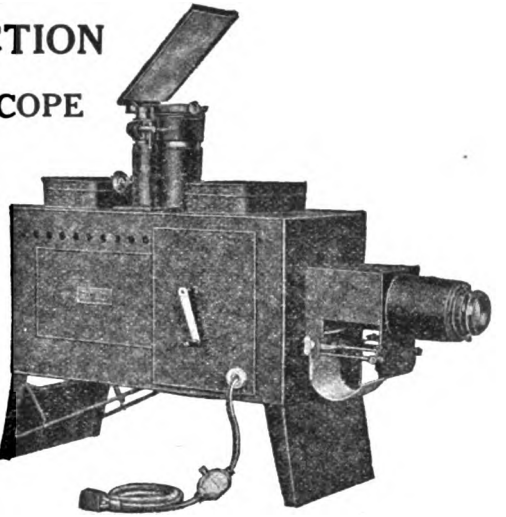
Digitized by Google

VISUAL INSTRUCTION
WITH
SPENCER DELINEASCOPE MODEL 3

is made perfect because it is an IDEAL STEREOPTICON for both lantern slides and opaque objects, such as pictures, post-cards, reading matter and objects of all kinds dead and alive.

IDEAL, because it embodies basic ideas (patented) possessed by no other. Example: Mechanical means of handling the slides, which does away with the antiquated lantern-slide holder and at the same time gives a "dissolving effect" on the screen unattained with other outfits except by using two stereopticons, one above the other.

One Spencer Delineascope does it.



Spencers Delineascope Model 3 for both lantern slides and opaque objects. 1,000 Watt Mazda bulb illuminant. **Price, $185.00**

SPENCER BUFFALO U.S.A.

SPENCER LENS COMPANY
Buffalo, New York

Manufacturers of **Microscopes, Microtomes, Delineascopes, Optical Glass, Scientific Apparatus, Etc.**

SPENCER BUFFALO U.S.A.

No. 2402

We Carry a Complete Stock of

Chemicals & Apparatus

for the

Physical

Agricultural

Chemical

Biological

Laboratory

We Excel in Equipping High School Laboratories.
Let Us Quote Prices on Your Next List of Requirements.

THE KAUFFMAN-LATTIMER CO.

41 East Chestnut Street
Columbus, Ohio

Digitized by Google

354. (*b*) The Sp. Gr. of salt water being 1.04, find how much fresh water must be added to a pint of it to reduce its specific gravity to 1.015.

10. A U-tube contains mercury in its lower portion.

Water is poured into one limb to a depth of 9 inches, and alcohol into the other to a depth of 10 inches, and the surfaces of the mercury in the two limbs are then in the same horizontal plane;

What change in the levels of the mercury in the tube takes place when two inches of alcohol are taken away?

(Sp. Gr. of mercury 13.6.)

11. How is Boyle's Law usually verified in the laboratory?

A cylindrical diving-bell 8 ft. high is let down into water until its top is 20 ft. below the surface of the water. To what height will the water rise in the bell, the water barometer standing at 33 feet?

PHYSICS.

Friday, June 25, 1920, 2 p. m. Two hours.

Answer ten questions as indicated below. No extra credit will be given for more than ten questions.

Indicate clearly your reasoning in each problem and state the units in which each answer is expressed.

Number and letter each answer to correspond with the question selected.

GROUP I

(Omit one question from this group.)

1. (*a*) Distinguish between mass and weight. (*b*) Could the fact that the weight of a body changes if it is taken from the equatorial to the polar region of the earth be shown by either a spring balance or a beam balance? Explain.

2. A body having a volume of 100 cubic centimeters and a density of 2.5 is fastened to a block of wood having a volume of 200 cubic centimeters and a density of 0.5. (*a*) What will the combination weigh when immersed in water? (*b*) What will the combination weigh when immersed in oil of density 0.9?

3. (*a*) Represent by a diagram a system of pulleys consisting of a double fixed block and a single movable block. (*b*) If the efficiency of the above system is 70 per cent, how great a weight can be lifted by a force of 30 pounds applied to the free end of the rope?

4. What horse power is required to run an automobile on a level road at the rate of 30 miles per hour if the forces of friction amount to 125 pounds?

GROUP II

(Omit one question from this group.)

5. (*a*) How are sounds produced and how are they transmitted to the ear? (*b*) How does the intensity of sound vary with change of distance from the source?

6. (*a*) If the lowest tone which the ear can recognize has a frequency of 16 vibrations per second what is the length of the longest wave the ear perceives in air at a temperature of 0°C.? (*b*) What effect, if any, does change in temperature produce in the velocity of sound in air?

GROUP III

(Omit one question from this group.)

7. (*a*) Define dew point. (*b*) What is meant by the relative humidity of the air? (*c*) How may the relative humidity of the air be experimentally determined?

8. If gas costing $1.00 per 1,000 cubic feet furnishes 600 B. T. U. of heat per cubic foot of gas burned, how much would it cost to raise from 62°F. to 212°F. one quart (2 pounds) of water by means of a burner and kettle having a combined efficiency of 50 per cent?

9. (*a*) Describe in detail an experimental method for determining the specific heat of a substance. (*b*) Explain how a numerical result may be secured from the data obtained.

GROUP IV

(Omit one question from this group.)

Digitized by Google

Everyday Texts

THE SCIENCE OF EVERYDAY LIFE

By EDGAR F. VAN BUSKIRK and EDITH LILLIAN SMITH, co-author with *Van Buskirk*

The project method of teaching is emphasized throughout the book, with the resulting opportunity for meeting individual interests, aptitudes, and needs of pupils. No elaborate equipment is required for the presentation of the course. The teaching equipment is unusually adequate. Used in such cities as:

New York	Chicago	Boston	Baltimore
Pittsburgh	Atlanta	Pueblo	Cincinnati
Washington	Madison	Logan	Kansas City
Des Moines	Toledo	Raleigh	St. Louis

EVERYDAY ARITHMETIC

By FRANKLIN S. HOYT and HARRIET E. PEET

The Advanced Book of *The Everyday Arithmetic* is an ideal text for the Junior High School. It gives practical studies of common business forms and practice, and lays a thorough and intelligent foundation in algebra and geometry which will prepare for a successful study of these branches of mathematics in the Senior High School.

Send for circulars of these series

Houghton Mifflin Company

Boston **New York** **Chicago**

10,000 Problems and Questions

Fifteen pamphlets compiled or edited by Franklin T. Jones

Price each pamphlet 50 cents, except Second Latin and English, 60 cents each. Sample copy to a teacher half price when money is sent with the order.

Write for discounts on orders for class use.

Algebra **Plane Geometry**
Chemistry **Solid Geometry**
Physics **Trigonometry**

Other Pamphlets

French A, French B; German A, German B; First Latin, Second Latin; English; Question Book on History; Medieval and Modern European History.

Ready Soon

American History and Civics **Ancient History**

In Preparation

General Science **General Information**

75,000 Already Sold. In Use in 500 Schools.

Address

THE UNIVERSITY SUPPLY & BOOK CO.

10109 Wilbur Ave.. Cleveland. Ohio.

Digitized by Google

10. In a darkened room a spectrum of sunlight is thrown on a screen. A bouquet of red, yellow, and blue flowers with green foliage is placed in the red end of the spectrum and gradually moved toward the violet end. State and explain what would be observed.

11. (*a*) Describe the construction and explain the operation of the so-called "pin-hole" camera. (*b*) If such a camera is 8 inches long and the image of a building 50 feet high appears as an image 3 inches high on the plate how far away is the building?

12. (*a*) Represent by a diagram the path of the rays of light through the lenses of an astronomical telescope. (*b*) A telescope has an objective whose focal length is 30 feet and an eye-piece whose focal length is 1 inch. What is the magnifying power of the telescope?

GROUP V

(*Omit one question from this group.*)

13. (*a*) Given one battery, one bell, two push buttons, and a quantity of wire, represent by a simple diagram a scheme for wiring a house so that the bell may be rung from either the front door or the back door. (*b*) Why is it advantageous to use a high voltage for the transmission of electric energy over long distances? (*c*) Why are alternating currents used for long distance electrical transmission?

14. A 17-candle-power carbon filament lamp takes 0.6 ampere at 110 volts. A 260-candle-power gas filled tungsten filament lamp takes 1.85 amperes at 110 volts. Compare the efficiencies of the two lamps.

15. The poles of a storage cell having an electromotive force of 2 volts and an internal resistance of 0.1 ohm are connected by two wires in parallel whose resistances are 12 ohms and 4 ohms respectively. (*a*) What current flows in each wire? (*b*) What current flows through the cell?

SOLUTIONS AND ANSWERS.

331. A Colt automatic bullet has a brass rounded point with lead back. If shot into the air, which end of such a bullet comes down first? Why? *Anonymous solution "from a soldier."*

Do you agree with him?

Problem on brass pointed bullet fired from Colt Automatic. Brass, 8.4 sp. gr. Lead, 11.37 sp. gr.

Bullets usually travel in the position such that the lighter or more sharply pointed part goes ahead and the heavier blunt part to the rear. Since the brass point is lighter than the lead at the rear, and also harder, it is natural to suppose that the brass rounded point travels ahead and comes down first. Further, it is unlikely that bullets would be so designed as to cause them to whirl end over end, as this would decrease their travel as well as their force. This whirling would result if the blunt heavy part were to go ahead.

335. *Test V, Physics, Society for the Promotion of Engineering Education,* (SCHOOL SCIENCE AND MATHEMATICS, January, 1920, page 177.)

Answers were *few.*

A professor in an engineering college had *all right.* A university graduate who teaches in a very prominent school had *seven* wrong and *one* not answered. A high school teacher of physics in a small town had *four* wrong.

339. *Test VI, Technical Information, Soc. Prom. Eng. Ed.,* SCHOOL (SCIENCE AND MATHEMATICS, April, 1920, page 369.)

Try this with any of your classes and send in the result.

The following answer was received which is published in full:

Dear Sir: I tackled those Carnegie Institute questions Test VI, published in the April SCHOOL SCIENCE AND MATHEMATICS and could answer all but five or six. As I have taught physics forty years and manual training more or less I was a little ashamed that I failed on any. I wonder how a lot of the other fellows did. Very truly yours,

A. A. UPHAM, Whitewater, Wis.

H. M. Snethen also sent in a report.

Send in your own experiences with this test.

Digitized by Google

Modern Junior Mathematics

By MARIE GUGLE

Assistant Superintendent of Schools, Columbus, Ohio

is the latest and most complete reorganization of the course in mathematics yet published. A three-book series, brand new from the ground up, equally suitable for junior high schools or for 7th, 8th and 9th grade classes. The book recognizes the modern trend in the teaching of mathematics, and follows very closely the recommendations of the National Committee.

Modern Junior Mathematics meets the child *as he is*. The series recognizes that advanced arithmetic demands a maturity of thought that places it rightly in the high school course of study; that, on the other hand, mathematical relations are taught best through experimentation and observation in the intermediate schools at the time when the pupils are primarily "doers."

THREE BOOKS

Book I is singularly happy in the elimination of stereotyped phraseology and archaic subject matter. The graph is used constantly to illuminate the different phases of arithmetic. The application of principles to every day business transactions is vividly presented.

Book II breaks absolutely with tradition. It introduces the subject matter in a new way. The pupil, doing and thinking for himself, learns to use formulas and algebraic expressions as convenient tools. He becomes familiar with the common geometric forms and grows to think naturally and without confusion in the terms and relations of geometry.

Book III, like the others, reflects the reorganization of such teaching necessitated by the phenomenal growth in popularity of the junior high school. The elements of arithmetic, geometry, algebra, and trigonometry are, more and more, being taught as one subject in seventh, eighth, and ninth years.

In this series Books I and II, while largely arithmetical and geometric, respectively, are not rigidly confined to one field or the other, and Book III, likewise, while largely algebraic, aims to give new meaning to arithmetic number relations and processes, while geometry continues to give meaning to algebra and offers with trigonometry an interesting field of application.

List prices, Book I—80c; Book II—90c; Book III—$1.00

Examination copies will be sent to any teacher, postpaid, upon receipt of 75 per cent of the list price. Samples may be returned for credit.

THE GREGG PUBLISHING COMPANY

NEW YORK CHICAGO BOSTON SAN FRANCISCO

Google

BOOK REVIEW.

Lighting from Concealed Sources, by J. L. Stair, Natural X-Ray Reflector Company, Chicago, Illinois. 246 Pages. 20x25 1-2 cm. Cloth. 1919.

This firm deserves a great deal of credit for perfecting an indirect method of illuminating, not only private homes, but public halls as well. As applied to school buildings, this method of illumination cannot help but increase the efficiency of the schools, enabling the pupils on dark days to receive the right kind of light and at the same time, remove the intense glare from direct illumination. This unquestionably will result in fewer headaches and a better concentration of pupils mind on the working question. The book is profusely illustrated, giving many views of interiors of different public buildings, stores, schools and private homes. There are 480 illustrations and drawings, showing the way in which the light is distributed.

It is a work which architects of public buildings and people who are contemplating not only outdoor lighting, but the interior lighting of new and old homes should secure and carefully study. C. H. S.

ARTICLES IN CURRENT PERIODICALS.

American Botanist, for August; *Joliet, Ill.*; $1.50 *per year*, 40 *cents a copy:* "The Desert Trumpet Flower," Willard N. Clute; "Notes on Comparative Regeneration in Elodea and Ceratophyllum," N. M. Grier; "Wildflowers of the Oregon Coast," R. V. Bradshaw; "Plant Names and Their Meanings," Willard N. Clute.

American Journal of Botany, for October; *Brooklyn Botanic Garden, Brooklyn, N. Y.*; $6.00 *per year*, 75 *cents a copy:* "Absorption of Moisture by Gelatin in a Saturated Atmosphere," Charles A. Shull and S. P. Shull; "Slow and Rapid Growth," H. S. Reed; "Cytology and Systematic Position of Porphyridium Cruentum Naegeli," Ivey F. Lewis and Conway Zirkle; "Somatic Chromosomes in Tradescantia," Lester W. Sharp.

Geographical Review, for November; 156th *Street and Broadway, N. Y.*; $5.00 *per year*, 50 *cents a copy:* "The Port of Paris," by Albert Demangeon (2 maps, 9 photos); "On Eskimo Stone Rows in Greenland Formerly Supposed to be of Norse Origin," by Morten P. Porsild (1 map, 2 diagrams, 4 photos); "Airplanes and Geography," Willis T. Lee (2 maps, 9 photos); "A Method of Aerophotographic Mapping," Fred H. Moffit (3 diagrams, 7 photos); "A New Series of Sunshine Maps of the United States," Robert DeC. Ward (1 map).

Physical Review, for October; *Ithaca, N. Y.*; $7.00 *per year*, 75 *cents a copy:* "The Tones from Bells," Arthur Taber Jones; "The Valency of Photo-electrons and the Photo-electric Properties of Some Insulators," M. J. Kelly; "The Detecting Efficiency of the Electron Tube Amplifier," E. O. Hulbert and G. Breit; "The Minimum Arcing Voltage in Helium," K. T. Compton, E. G. Lillym, P. S. Olmstead; "Electrification by Impact," Harold P. Richards; "A New Design of Precision X-Ray Spectrometer," C. D. Cooksey; "The Performance of Conical Horns." G. W. Stewart; "The High Frequency Spectra of Lead Isotopes," C. D. Cooksey and D. Cooksey; "On the Variation of the Factor h in the Equation $\frac{1}{2}mv^2 = hv$," Fernando Sanford; "A Study of Residual Ionization in a Gas with Reference to Temperature Effects," C. H. Kunsman.

Popular Astronomy, for November; *Northfield, Minn.*; $5.00 *per year*, 50 *cents a copy:* "Dedication of Observatory at Case School of Applied Science," with Plate XXII, K. O. Thompson; "Definition and Resolution," William H. Pickering; "Twenty-Fourth Meeting of the American Astronomical Society," with Plate XXIII, Continued; "Occultations of Stars by the Moon," Frederick R. Honey.

School Review, for November; *The University of Chicago Press;* $2.50 *per year*, 30 *cents a copy:* "Americanization in the Thornton Township High School," Lewis W. Smith; "The Peculiar Functions of the Junior High School: Their Relative Importance," Leonard V. Koos; "Faculty

Digitized by Google

Wiese Laboratory Furniture Co.

Engineers and Builders

Educational and Technical Furniture for Physics, Chemistry, Agriculture, Biology, Household Economics

The art of building laboratory furniture is as definite and exact as science itself. The Wiese factory is prepared to furnish durable, satisfaction-giving laboratory equipment of standard design or special order

Without cost or obligation to you, we extend the services of our engineering department in planning your laboratories. To make sales is not enough—we want to make friends

Write for Our
New Catalog No. 24

WIESE LABORATORY FURNITURE CO.

Sales Office:
20 E. Jackson Blvd. :: Chicago, Illinois

Factory:
Manitowoc, Wisconsin

Digitized by Google

Organization in the Theodore Roosevelt High School," B. C. Richardson; "The Dalton Plan," E. D. Jackman; "Harlan's American History Test in the New Trier Township Schools," G. L. Griffith.

Scientific Monthly, for November; *Garrison, N. Y.*; $5.00 *per year*, 50 *cents a copy*: "The Role of Physiolography in Military Operations," Kirk Bryan; "Growth of New York and Suburbs Since 1790," James L. Bahret; "Education and Learning in America," Arthur Webster; "The British Association for the Advancement of Science:" "Fossils and Life," Dr. F. A. Bather; "Heredity," Miss E. R. Saunders; "The Supply of Oxygen to the Tissues," J. R. Barcroft; "Intensive Cultivation," Frederick Keeble; "The Problems of Anthropology," Karl Pearson; "The Individual Child and Methods of Teaching," Sir Robert Blair; "Evolution's Most Romantic Moment," Roy L. Moodie; "An Ancient Moonfish," Dr. David Starr Jordan.

ASSAILS AMERICAN TEACHING METHODS.

Defects in the American schools were sharply criticized in a recent paper "The Education of the Research Chemist," read by Dr. Robert E. Rose, a research chemist connected with the E. I. du Pont de Nemours Company of Wilmington, Del., before the Dye Division of the American Chemical Society at the University of Chicago.

"The education of the men," said Dr. Rose, "who are to lead the dye industry to future successes is a matter of vital interest to us. The subject is equally of interest, in its general aspects, to all who teach and to all who are concerned with commercial enterprises founded on the technical application of the results obtained by research.

"The dye industry in this country was established with the aid of research men who were not trained for this special line of work; they were men of general training and their adaptability to their new duties throws a very interesting light on the educational system of which they are the products.

"They were very successful, let that be emphasized, but at the same time let us study such faults as were apparent in order that we may learn how to improve the training given in our schools.

"The worst failings were a tendency to overlook trifling indications such as slight differences in color or structure or smell, and a disregard for the necessity for reasoning precisely and understanding clearly before doing any experiments, that is, there was a lack of exact observation coupled with rather vague reasoning.

"Of course, this was not true of the maturer men, but rather of those fresh from the training of the university. The causes of these faults lie very far back in our methods of teaching. Research is nothing strange; it is simply the use of the results of well trained powers of observation by a mind capable of clear reasoning. The child who by the careful examination of a mechanism, learns how it works, is applying the methods of research. The chemist examines the substances of which the world is composed, finds how they are put together and learns how to make new ones. The essential of this kind of work is well trained senses, and the development of the senses is very largely determined during the years of early childhood. It is for this reason that we may say that the research man is made or marred during childhood and adolescence. However, we do not make a great effort to train the senses during childhood; instead we put a premium on developing the memory and formal methods of reasoning. Later in high school and university we continue to give the student too many second hand facts instead of making him observe for himself. We teach him to reverence the opinion of others rather than his

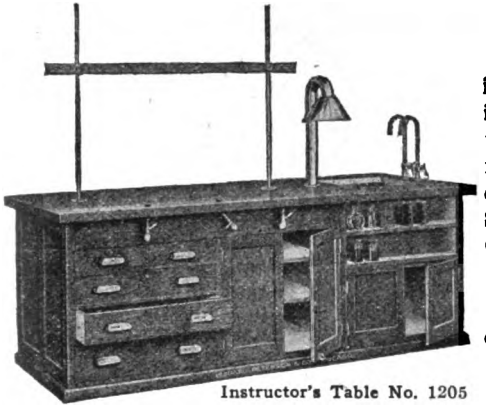
Digitized by Google

Leonard Peterson & Co. *Inc.*

Pioneer Designers and Manufacturers of

High Grade Laboratory Furniture

For Chemistry, Physics, Biology, Physiography, Domestic Science, Domestic Art, and Manual Training.



Instructor's Table No. 1205

Superior quality, strength, solidity, and durability are built right into our furniture. Every detail is well worked out. Our furniture has met with the approval of hundreds of educators thruout the United States, Canada, Porto Rico, and China.

Send for a copy of our general catalog No. 10.

Leonard Peterson & Co., Inc., 1234-48 Fullerton Ave., Chicago

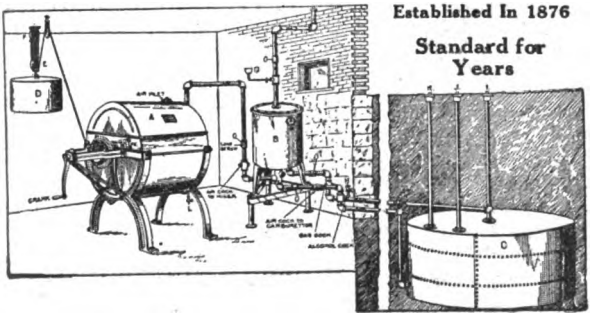
MANUFACTURERS OF GUARANTEED LABORATORY FURNITURE

New York Office: Grand Central Palace, New York City

Back numbers of School Science, School Mathematics, and School Science and Mathematics may be had for 30 cents a single copy. The Mathematical Supplements for 15 cents a copy.

In sets the prices are, postpaid:

School Mathematics and Supplements, Vol. I, five numbers	$1.00
School Science, Vol. I, eight numbers	6.00
School Science, Vols. II and III, each	6.00
School Science, Vol. IV, three numbers	.75
School Science and Mathematics, Vols. V, VI, VII, VIII, IX X, XI, XII, XIII, XIV, XV, XVI and XVII, each	2.00
School Science and Mathematics, Vols. XVIII and XIX	2.50



Established In 1876

Standard for Years

This Machine Will Produce

Automatically

GAS

For your laboratories, Domestic Science Department and for lighting.

* * *

In use in hundreds of educational institutions throughout the country.

Write to us for a list of colleges and high schools using our machine.

Illustrated Catalogue Will be Sent on Request.

MATTHEWS GAS MACHINE CO.

180 N. Dearborn Street, CHICAGO, ILLINOIS

Please mention School Science and Mathematics when answering Advertisements.

Digitized by Google

own and thereby kill that healthy skepticism which is the essence of research.

"The courses in chemistry are apt to call for an exercise of memory rather than of reasoning, though they are better in this country than in any other. The future dye chemist is called upon to learn many formulas by eye without being given a good understanding of their real meaning. Finally, the research work in our universities is hampered by the routine duties placed on the teaching staff and therefore we find very few institutions which can be regarded as great schools of research where many men learn from each other the enthusiasm of the true investigator. We are too apt to regard research as fulfilling, in part, the requirements for the degree of Doctor of Philosophy, instead of adding to the sum of human knowledge.

"The remedies are easy to state but hard to apply. The teaching of observation, the training of the senses can be done properly only by really efficient grade school teachers, with the cooperation of parents. Some day we shall recognize the fact that the school teacher is of more importance to our supply of research men than is the college professor. Some day we shall admit that schooling, though intangible, is worth more than railroads, mills, and all other material things save only food and that it is worth paying for. When we shall have better dye chemists.

"In the high schools and universities, we need a higher average of excellence in the teaching staffs. There are very many extremely able men, but there are also many unambitious, rote teachers who teach because they find it easier to do that than anything else, men who are never up-to-date. We need better text books, especially of organic chemistry—we have nothing in this line which is in keeping with the modern development of applied organic chemistry. I do not mean a technology, but a text giving due emphasis to the applications made of knowledge expressed in the facts and theories of the class room.

"To foster pure research we should have institutions set aside for research, institutions to develop, as the years pass, into great schools wherein the advance of the science will be aided by all the resources of the nation.

"The teaching of research is a subject of interest to all, because the measure of the success of a nation is the quality and number of her trained specialists. It is of special interest to us because the industry to which we are devoted needs, more than any other, a great number of capable research men. It is for that reason I address this paper to the Dye Section of the American Chemical Society."

AMERICAN RED CROSS—WHY THE COLLEGES SHOULD SUPPORT THE RED CROSS.

When America went into the war there was an immediate rush of college men to take their places on the firing line. By fall 150 institutions reported that 13,520 students were in the army or navy, and 1,650 had gone into non-military activities. Whereas the undergraduates for the most part went into active service, the alumni, or those of them who for one reason or another were unfitted for army or navy, went into the service of the relief organizations.

Hundreds of college men and women went into the Red Cross. In fact, this organization was largely made up of college personnel. They went into it because it was constructive, because it gave them a chance to apply practically those ideals which are the ideals of America, and which the training they have received in colleges and universities has taught them to honor and cherish.

Digitized by Google

School Science and Mathematics

Member of the Educational Press Association of America

No Numbers Published for JULY, AUGUST and SEPTEMBER.

PRICE. The subscription price is Two Dollars and Fifty Cents a year, if paid in advance; single copies 30 cents.

ALL REMITTANCES should be made payable to the order of **School Science and Mathematics. Remittances should be made by Post Office Money Order, Express Order, or Bank Draft.** If personal checks are sent, please add ten cents for collection.

SCHOOL SCIENCE AND MATHEMATICS is the "official organ" of the following associations: The Central Association of Science and Mathematics Teachers, Eastern Association of Physics Teachers, The Physics Club of New York, Missouri Society of Teachers of Mathematics and Science, Science and Mathematics Section of the Oregon State Teachers Association, Saskatchewan Science and Mathematics Teachers Association, Southern Pacific Science and Mathematics Teachers Association, Kansas Association of Mathematics Teachers New York State Science Teachers Association, New Jersey Science Teachers Association.

POSTAGE IS PREPAID for all subscriptions in the United States and Mexico. For Canada add 25 cents for postage. For all other countries in the Postal Union, add 50 cents.

CHANGE OF ADDRESS. Subscribers should send notice of any change of address before the 12th of each month; otherwise they are held responsible for magazine, sent to their former address, and no duplicate copies will be sent except on payment of 30 cents for each copy. Send notices to School Science and Mathematics, Mount Morris, Ill., or 2059 East 72nd Place, Chicago.

MANUSCRIPTS. Contributions on Science and Mathematics Teaching are invited. Articles must be written on one side of the sheet only. All illustrations must be drawn or written in jet black on a separate sheet of manuscript. Contributors are requested to write scientific and proper names with particular care. Manuscripts should be sent to the Editor of **School Science and Mathematics, 5517 Cornell Ave., Chicago,** or to the proper departmental Editor. Books and pamphlets for review should be sent to the Editor. To insure insertion in any number, manuscript must be in the editor's *possession not later than the 20th of the second month before* publication.

MISSING NUMBERS will be replaced *free* only when claim is made within thirty days after receipt of the number following.

REPRINTS, if desired, must be ordered in advance of publication. Reprints of leading articles will be printed as ordered, the actual cost (with cover, if desired) to be paid for by the author. Reprints *must* be *paid* for when ordered. The table below shows the *approximate* cost of reprints consisting of plain text or text with line engravings. The actual cost may vary from the figures given and will depend upon the amount of work in re-making the pages into forms, press work, paper, printing, etc.

Number of Copies	100	Extra Hundreds	Number of Copies	100	Extra Hundreds
2 pages	$1.50	$0.25	16 pages	$6.65	$1.35
4 pages	2.10	.45	20 pages	8.70	1.55
8 pages	4.30	.80	Cover, extra	2.75	.45
12 pages	6.00	1.20			

SCHOOL SCIENCE AND MATHEMATICS

PUBLICATION OFFICE **MOUNT MORRIS, ILLINOIS**

Business Office, 2059 72nd Place, Chicago.

Editorial Office, 5517 Cornell Ave., Chicago.

Digitized by Google

And then the war ended. A good many people thought that the Red Cross would end too. But disease and suffering did not end with the war. Health and good citizenship are as important today as they were two years ago. And so the Red Cross work goes on. It still stands for the ideals of America—the ideals which it is the privilege and the duty of every university man and woman to further and cherish.

It is the duty and the privilege, therefore, of every college student to stand back of the Red Cross, to aid it in every way possible in its after-war campaign for a healthier and happier America. The Annual Red Cross Roll Call will be held November 11-25. Ten million Americans joined or renewed their memberships last year. The Red Cross counts on its college friends to join, again, this year.

AIMS OF MODERN GEOGRAPHY TEACHERS.

By E. E. Lockey,

State Normal School, Wayne, Nebraska.

If we are to play our parts well as good citizens in the new social and economic order into which we are moving, it is quite necessary that we become thoroughly conversant with the life and problems of the peoples with whom we are associated. The world is becoming smaller every day. We hear from neighboring towns about once a week, but from France, Russia, and China every day. What happens in Europe this morning we may have in this morning's paper. Since we can keep ourselves informed concerning important affairs in Europe or South America as easily as we can keep up on the community gossip, it seems that the whole world has really become one large neighborhood of interesting and interdependent folks. Society will expect the educated man or woman of the future to understand well the social and economic ties that bind the peoples of the world together into one large unity. If our children are to develop into worthy leaders for the future, it is our duty to provide ample opportunity for them to study these problems. What can our schools offer children that will satisfy this pressing need? The answer is evidently more and better geography. The trend of modern geography is well shown in the following statement of aims.

1. Geography should seek to create in the children an abiding interest in how the people of different countries live, their important industries, their fine achievements, their pleasures, their leisure time activities, and the reciprocal duties and responsibilities that exist between them and us.

2. It should give pupils a mastery of geographic facts and principles so they will be able to explain the operation of the interacting phenomena noted in connection with the developing of important industries, the location and growth of leading cities, and the interdependence of the peoples in different parts of the world.

3. It should produce a social orientation in the lives of the pupils such as will lead them to a sympathetic study and understanding of peoples and races other than their own.

4. It should determine for the pupils whether or not a people are using wisely the resources nature has given them, how they may improve their opportunities, and what we may do to assist them.

5. It should give such a thorough training in the use of the tools of the subject, namely, maps, texts, reference books, government bulletins, etc., that the pupils may become independent workers in the solution of geographic problems.

Training in this kind of geography will furnish vital material with which to develop an intelligent citizenship that will find equitable adjust-

Digitized by Google

LABORATORY APRONS

Send for Descriptive Circular and Prices

CANVAS PRODUCTS CORP.
SCHOOL DEPT.
Fond du Lac, :: Wis.

School Science and Mathematics does all kinds of printing and engraving. We will be glad to do your work. You will be sure of good work if done from our Plant. Give us a trial

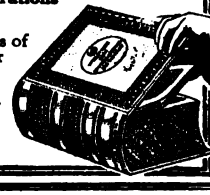
Here's the Foundation Book
For every teacher
For every school
WEBSTER'S NEW INTERNATIONAL DICTIONARY

When questions arise in the history recitation, in language work, in spelling, or about noted people, places, foreign words, synonyms, pronunciation, new words, flags, state seals, etc., do you suggest that this Supreme Authority is a universal question answerer and contains just the information desired?

400,000 Vocabulary Terms. 30,000 Geographical Subjects. 12,000 Biographical Entries. 6,000 Illustrations and 2,700 pages.

Write for Specimen Pages of Regular and India-Paper Editions, Prices, etc.

G. & C. Merriam Co.
Springfield, Mass.
U. S. A.



MODELS—Development of Frog

We are making models of all kinds.

We have just placed on the market a set of 16 models illustrating the EMBRYOLOGICAL DEVELOPMENT OF THE COMMON FROG.

The first preparation of the set is a panel 8x10 inches, showing in complete detail the reproductive system of the female frog. Then follow single-celled egg, 2-cell, 4-cell, 8-cell, 16-cell, 16-cell cross-section, 64-cell, blastula, yolk-plug and later stages, including longitudinal section of the very young tadpole, and 10-inch figure of external gill stage.

They are all large enough to be seen throughout the class-room.

They are all beautifully mounted and colored, Ectoderm, Entoderm and Mesoderm are sharply contrasted.

The sets are made by an expert embryologist and are accurate in every detail. They will stand heat and rough handling. They are guaranteed to satisfy you.

Write Today for Circular

The General Biological Supply House, Inc.
1177 East 55th St. :: :: :: Chicago, Ill.
Western Representatives of the Supply Department of Marine Biological Laboratory, Woods Hole, Mass.

Digitized by Google

ment for the intricate difficulties that are being forced upon us by the world's becoming smaller every day, and by our neighbors crowding us from every side.

The reason that geography training has not produced better results in terms of the aims here set forth is largely due to the fact that we have thoughtlessly conceived the value of geography to be individual and mercenary rather than mutual and altruistic; and that we have never realized that the purposes of geography might include definite provision for proper social orientation in the world of increasingly interdependent workers as well as for physical orientation in the world of objects.

In the new world order that is upon us, geography occupies a unique place. It is the chief subject upon which we may depend for the moral teaching of these complex human relationships. It occupies a field that is peculiarly its own. One may search through the other subjects of the common school, in vain, to find any systematic attempt to present a comprehensive view of the home, the life and work of the Brazilian or any other modern peoples. The program of the new era calls for the elimination of international strife and jealousies, and the substitution of friendship and the cooperative spirit. The place to begin the rehearsal of this program is in the geography class of the elementary school.

Organization to avert international conflict in the future must provide for a better understanding between races and peoples. Geography deals with the activities of modern peoples as they are busying themselves in the noble task of providing the world with the necessities of life. The better we understand our relationships in connection with these activities, the better we will be able to adjust our conflicting interests without appeal to arms. Intelligence alone will never make the world safe for democracy. It is only when intelligence is tempered with virtue that the world will be safe indeed.

The program for the new geography is a complete one. It provides for a study of man not only in relation to the economic and industrial phases of his physical environment but rounds out and completes the program by introducing the most vital and necessary element in the whole field of geography, namely, the social and moral obligations that perforce go with such closely interwoven human interests. To be sure, some of these problems are too complex and difficult for elementary pupils, but there are simple and easily understood phases of the social and moral elements of geography that we dare not omit, even in the elementary school. Let it be said that this generation not only had the physical and moral courage to crush the head of autocratic government in the world, but that, along with the many other worthy provisions looking to the future security of the world, it was wise enough and good enough to organize a complete program for geographical training, one calculated to take full advantage of geographical knowledge in introducing the moral and social corollaries that should accompany geographical principles.

THE NEW PEDAGOGY.

"Reginald, what did you study in school today?"

"We had two films of history and one reel of geography, Ma."

This joke when it appeared in the papers some years ago was the cause of a great deal of laughter; no one ever dreaming that it would come true in their time, but as with many another joke, such as the "horseless carriage," the truth is stranger than fiction and we are now in a position to witness the very thing that was so laughingly spoken of yesterday, for New York City is to have a regular film course beginning with the fall

Digitized by Google

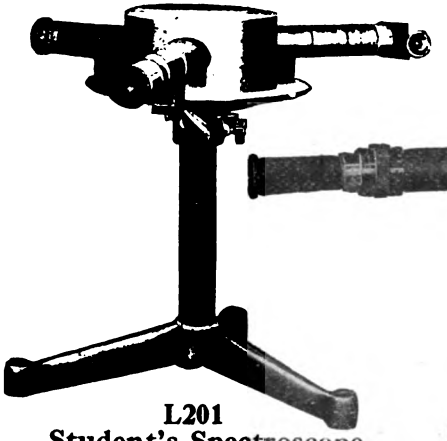
AMERICAN-MADE

Spectroscopes *and* Spectrometers

For Sale by All Dealers

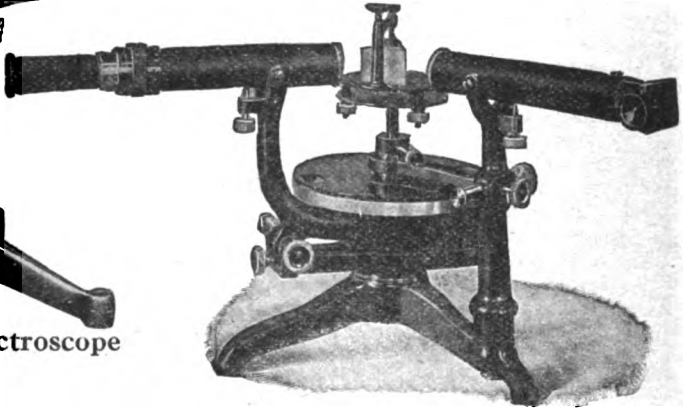
GRATIFYING approval has been accorded by the teaching profession and by industrial laboratories to the Gaertner type of Spectroscopes and Spectrometers, each of which instruments is produced in two most-used models, the one for student, the other for laboratory use.

Our current lot of Spectroscopes of both models is oversold, and an additional quantity of each is in work. So, also, with the Student's Spectrometer, but orders for quick delivery can still be accepted on L105, the Laboratory Spectrometer, while delivery on the other three will not be long delayed.



L201
Student's Spectroscope

L101
Student's Spectrometer



These instruments, in their elegance, simplicity and precision of workmanship, set a distinctly American mode in instrument-making, embodying, as they do, the best in foreign practice, along with the utmost of worth-while individuality that the maker's many years' experience has been able to contribute thereto.

These Spectroscopes and Spectrometers are made also in models of greater precision for special use, and amongst these others we look forward to completing, during 1920, our New Wave Length Spectrometer, advance orders for which will be filled in rotation as received.

For full information we refer to our Catalog "L" of Optical Instruments.

William Gaertner & Co.

5345-5349 Lake Park Avenue, Chicago, U. S. A.

Digitized by Google

term of September. After conferring with representatives of all the motion picture companies interested in educational subjects, Dr. Ernest Crandall, Director of Visual Instruction of the Board of Education, has selected T. K. Peters of this city to furnish the city schools with regular courses in biology, geography, English, and other subjects. These courses have been prepared by Mr. Peters as the result of nine years study and work along educational film lines and are so arranged as to supplement existing standard textbooks as used in every state in the Union. The biology course will consist of 22,000 feet of film and will be shown one subject every day during the entire school term. The geography course consists of about 50,000 feet of film. Ten schools have been selected as a start, but the number will be increased from time to time. Other courses have been prepared and will be released as fast as facilities are available for their distribution.

GEOLOGY AND WAR.

Modern scientific warfare compels an army to seek every possible advantage by making full use of all sources of information about the physical conditions within the theater of operations. Of two opposing armies the one having the better knowledge of the terrain will have the advantage—at times a decisive advantage. A complete knowledge of the terrain is, however, possible only by the use of geology.

The principal applications of geology to military problems are as follows:

(1) The determination of water resources, both underground and surface, at the front and along the line of communication.

(2) The determination of the physical character of soil, subsoil, and bedrock, and the presence or absence of underground water, with relation to their effect on fieldworks, including trenches, dugouts, and mines.

(3) The distribution, occurrence, and quantity of road metal, ballast, and material for concrete.

(4) The determination of the physical character of soil and subsoil during wet and dry seasons, with relation to its influence on the movement of large bodies of troops and of artillery and tanks.

Practically all uses of geology fall within the above general classification. It is evident that any engineering project involving extensive excavation may call for geologic knowledge. It is evident, too, that the sanitation of camps and cantonments must take cognizance of the underground drainage conditions as well as of water supply and surface formations. It has been found that certain geologic conditions, by furnishing good electric transmission, favor the use of the listening devices that were extensively used during the period of trench warfare in the World War.

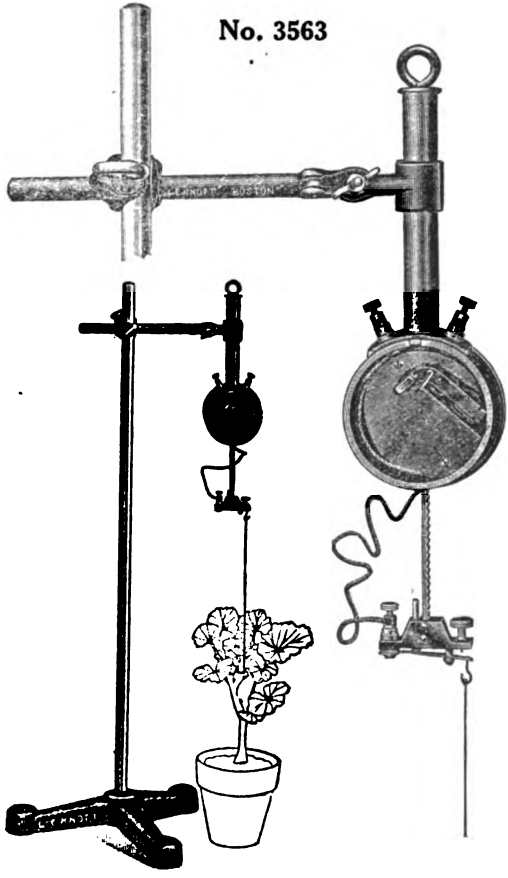
Though the application of geology to war seems to be almost self-evident, it was not recognized prior to the outbreak of hostilities in Europe. The utility of the science to an army in the field soon became evident, however, and before the end of the war nearly all the great powers had organized geologic staffs. A staff of 18 geologic engineer officers had been authorized for the American Expeditionary Force, of whom 11 had been inducted into the service in France.—[*U. S. Geol. Survey.*

USES OF PEAT.

Devotees of the automobile and motor boat will be glad to know that successful experiments have been made in Sweden in extracting wood alcohol from peat. The process as reported by the commercial attaché at Copenhagen, Denmark, is described in a report on peat in 1919 recently issued by the United States Geological Survey, Department of the Interior. Interesting instances of the use of peat as a fuel are given in this report. A coastwise steamship company of Norway, for example, during the coal shortage was enabled by the use of peat fuel to keep up its full sailing schedule.—[*U. S. Geol. Survey.*

Digitized by Google

BOVIE
PRECISION AUXANOMETER



An invention of Dr. W. T. Bovie of Harvord University, for recording the growth of plants.

The Bovie Precision Auxanometer consists essentially of a device which is carried upward as the plant grows. When the device has moved a certain distance, it closes an electric circuit, which operates the recording pen of the chronograph. This arrangement makes it possible to have the recording mechanism at any desired distance from the plant and to make simultaneous records of a number of plants or of various parts of the same plant.

The instrument is light, compact and quickly set up for use and, as the force of gravity is not utilized for moving any of its parts, it may be set at any angle with the vertical so that growth in any direction may be measured and recorded. Records of each 0.1 mm. of growth can be made and the instrument will be found reliable in or out-of-doors. The experimental model was run by Prof. Bovie the entire summer in the garden exposed to the weather, the brass case being open part of the time so that the internal mechanism was exposed.

Complete specifications furnished on request.

Furnished in plush-lined polished hardwood box with hinged cover, price **$48.50**

L. E. KNOTT APPARATUS COMPANY

BOSTON (Cambridge "A" Station) MASS.

Digitized by Google

RANKEN TAKES TWO! The Ranken School of Mechanical Trades, St. Louis, recently appointed our candidates to head their Science and Mathematics Departments. We fill choice positions in all states. Get a better position thru us in 1921. Details gladly given.

SPECIALISTS' EDUCATIONAL BUREAU

ROBERT A. GRANT, President
ODEON BLDG. ST. LOUIS, MO.
Pacific Coast Office: Berkeley, Calif.

A BUREAU FOR SPECIALISTS

TEACHERS AGENCY
28 E. Jackson Blvd., Chicago
Boston New York Birmingham Denver Portland Berkeley Los Angeles

To this organization—national in scope—employers and teachers naturally turn in making a survey of the whole educational field for best teachers and teaching opportunities.

Teachers, We Need You
FREE ENROLLMENT
ROCKY MOUNTAIN TEACHERS' AGENCY
Home Office: 326 Empire Bldg., Denver, Colo., Wm. Ruffer, A. M., Mgr.

OTHER OFFICES
Portland, Ore.: 1312 Northwestern Bank Bldg., Frank K. Welles, Mgr.
Los Angeles, Cal.: 636 Chamber of Commerce, John C. Epperson, Mgr.
Chicago, Ill.: Lytton Bldg., 14 E. Jackson Blvd., H. S. Stice, Mgr.
Minneapolis, Minn.: 327 14th Ave. S.E., F. B. Reed, Mgr.
Kansas City, Missouri.

EDUCATION
40th year Sept. 1919. $3 a year. Sample 20c.
120 Boylston St., Boston, Mass.
"AS NECESSARY TO A TEACHER AS A MEDICAL JOURNAL TO A PHYSICIAN"

SOUTHERN TEACHERS' AGENCY
Columbia, S. C. — Richmond, V. A. — Chattanooga, Tenn.
Covers the South
Special Enrollment
New Booklet

6534 WESTERN REFERENCE TEACHERS WANTED

DURING 1918-19 we received official requests from employers in forty three states and four foreign countries for 6,534 teachers for Schools and Colleges from Kindergarten to University. OUR EIGHTH YEAR OF RECOMMENDING ONLY WHEN ASKED TO DO SO BY EMPLOYERS DIRECT. This is why OUR MEMBERS are usually chosen. They are wanted. No enrollment fee necessary. If you want a position with the Progressive Employers who depend upon our Professional Service for teachers you must use the same service they use.

THE WESTERN REFERENCE & BOND ASSOCIATION
394 Journal Building, Kansas City, Mo.

Sargent's Handbook of American Private Schools

An Annual Survey and Review critically describing Private Schools of all classifications and Summer Camps for Boys and Girls.

A Compendium for Educators and all interested in Education.

A Guide Book for Parents supplying intimate information, which makes possible a discriminating choice.

Comparative Tables give the relative cost, size, age, special features, etc.

Introductory Chapters review interesting developments of the year in education.

Educational Service Bureau will be glad to advise and write you intimately about any School or Camp in which you are interested. Write full particulars. Consultation by Appointment.

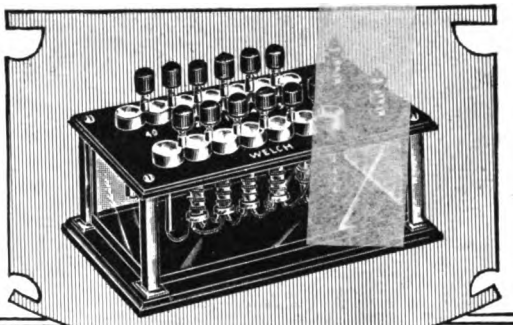
6th Ed., 860 pp., round corners, silk cloth, $4.00.

Circulars and Sample Pages on Request

PORTER E. SARGENT, 14 Beacon Street, BOSTON, MASS.

Please mention School Science and Mathematics when answering Advertisements.

Digitized by Google



QUALITY WELCH SERVICE

A Sign of Quality

QUALITY WELCH SERVICE

A Mark of Service

Who Uses Your Equipment?

It Is Not the teacher who selects it, not the Board of Education who buys it, nor the parents who pay for it, but the student.

It Is the inexperienced, untrained student who does not know how to care for instruments of precision, who learns by trying and who often mishandles it.

Every Welch Instrument is designed for just such use—*including the misuse.* Quality clear through—*built for service*—economy in the long run—and a guaranteed product as indicated by the trade mark.

W. M. WELCH MANUFACTURING COMPANY

Manufacturers, Importers and Exporters of Scientific Apparatus

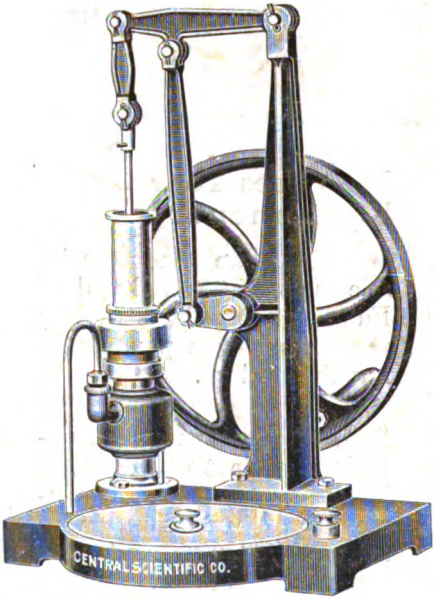
1516 ORLEANS STREET, CHICAGO, ILL., U. S. A.

Digitized by Google

THE ATMOSPHERE

is one of the most important topics in the subject of Physics and one of the most interesting to the student. How to properly present the topic so as to capitalize this interest and utilize the knowledge gained for the proper understanding of more difficult related topics, such as molecular motion, heat energy, vaporization and condensation, steam and gas engines, etc., offers no difficulty to the laboratory which is equipped with a

CENCO-GERYK AIR PUMP



No. 10994, $75.00

Some of the questions raised by the student which can be readily demonstrated by the use of this pump are:

1. Does air have weight?
2. Does air exert pressure?
3. How much pressure?
4. Can water be "sucked" from a bottle?
5. What would happen to a liter of air if turned loose in an empty room?
6. Why is it impossible to boil eggs "hard" at the top of a high mountain?
7. Why do balloons sometimes burst when high up in the air?
8. Why do divers' ear drums sometimes burst when they come to the top?
9. Why are you inclined to swallow several times in going up or down in an elevator or when a train enters a tunnel?
10. Why do the windows of a house generally fall outward when a tornado strikes it?
11. What causes the water to follow the piston of a lift pump upward?
12. How high can water be pumped with a lift pump?

Many other questions of interest to the student can be easily and finally disposed of by means of this pump.

Full description will be found in Catalog F 22.

USE CENCO BUILT APPARATUS IN YOUR LABORATORY AND LECTURE ROOM

IMPORTANT!!! See special announcement on page 774

CENTRAL SCIENTIFIC COMPANY

LABORATORY Apparatus CENCO Chemicals SUPPLIES

460 E. Ohio St., Chicago, U.S.A.

Digitized by Google

Digitized by Google

Digitized by Google

Digitized by Google

Digitized by Google

BOUND

SEP 17 1923

UNIV. OF MICH.
LIBRARY

UNIVERSITY OF MICHIGAN
3 9015 06817 4013

Digitized by Google